IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

POLAROID CORPORATION Plaintiff, v. HEWLETT-PACKARD COMPANY, Defendant.	)	C.A. No. 06-738 (SLR) **REDACTED – PUBLIC VERSION**

PLAINTIFF'S ANSWERING BRIEF IN OPPOSITION TO DEFENDANT'S MOTION FOR SUMMARY JUDGMENT OF NON-INFRINGEMENT, OR, IN THE ALTERNATIVE, PATENT INVALIDITY

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NATURE AND STAGE OF THE PROCEEDING

Defendant Hewlett-Packard Company ("HP") filed a motion for summary judgment that its accused products do not infringe Claims 1 3 and 7 9 of Polaroid's U. S. Patent No. 4,829,381 ("the '381 patent"), or, in the alternative, that the '381 patent is invalid. This is Polaroid's answering brief in opposition to that motion.

SUMMARY OF THE ARGUMENT

1. HP supports its motion for summary judgment with only unsubstantiated attorney argument. A movant cannot meet its burden that it is entitled to judgment as a matter of law with attorney argument alone. *Invitrogen Corp. v. Clontech Laboratories, Inc.*, 429 F.3d 1052, 1068 (Fed. Cir. 2005). Because HP fails to provide sufficient evidence to support its motion for this reason alone HP's motion for summary judgment should be denied. *See id.*

2. Even assuming that HP had provided actual evidence rather than attorney argument, HP's only argument for why it is entitled to summary judgment of non-infringement is that its accused products do not contain a claimed ratio $\frac{Av}{M}$, where A_v is the local average of a group of pixels and M is any value within the dynamic range. With respect to Claims 1 3, the claimed ratio is found in the "means for selecting and transforming" claim element. HP's argument that it does not perform the function of this means-plus-function claim element because its accused products do not have the claimed ratio fails under either party's claim construction. [redacted] This is the same ratio that is required by

the claims. Both parties agree that the numerator of the claimed ratio is the local average of a group of pixels. They disagree, however, as to the construction of the denominator of the ratio. Under Polaroid's construction, the denominator of the ratio, M, is any value between 0 and 255 for an 8-bit image [redacted] Thus, HP's algorithm performs the identical function of the "means for selecting and transforming" claim element under Polaroid's proposed claim construction.

3. Under HP's claim construction, the denominator of the ratio contained in the "means for selecting and transforming" claim element equals 256. There are insubstantial differences between a ratio with the actual values that HP uses in the denominator and a ratio with a denominator of 256. Thus, HP's algorithm performs the function of this claim element under the doctrine of equivalents.

4. The structure corresponding to the "means for selecting and transforming" claim element under both party's proposed claim construction includes the specific ratio A_v/M, where A_v is the local average of a group of pixels and M is a value between 0 and 255. [redacted] If a decimal is the same as a ratio, HP's LACE algorithm literally infringes this claim element under Polaroid's construction. Even if a decimal is the structural equivalent to a ratio, HP's LACE algorithm literally infringes this claim element under Polaroid's construction. In either case,

[redacted]

under HP's claim construction, HP's accused products infringe this claim element under the doctrine of equivalents. HP's argument in support of summary judgment for Claims 2 and 3 is the same as that for Claim 1. Thus, HP's motion for summary judgment of non-infringement of Claims 1 3 should be denied.

5. Claims 7 9 require a ratio of the average of a group of pixels "over" (per Polaroid) or "divided by" (per HP) a value that ranges between 0 and 255 for an 8-bit image. [redacted] Thus, HP's LACE algorithm literally meets this limitation under either party's claim construction. Thus, HP's motion for summary judgment of non-infringement of Claims 7 9 should be denied.

6. To anticipate a patent claim, a single prior art reference must expressly or inherently disclose each claim limitation. *Commissariat a L'Energie Atomique v. Samsung Elecs. Co.*, 524 F.Supp.2d 546, 549 (D. Del. 2007). Okada does not anticipate the asserted claims. The examiner allowed the '381 patent to issue after reviewing the Okada reference. The examiner specifically stated that Okada did not teach every element of the invention claimed in the '381 patent. Okada differs fundamentally from the invention disclosed in the '381 patent because Okada does not teach the use of a local average to provide a unique gamma curve for each pixel in an image. For this reason alone, HP's invalidity claim is meritless. In addition, Okada does not expressly or inherently teach the algorithms disclosed in the '381 patent for transforming an image, and HP's summary judgment motion must be denied for this separate and independent reason.

7. Okada does not render the asserted claims obvious because a person of skill in the art would not have been motivated to modify the teachings of the Okada reference to achieve the

[redacted]

invention claimed in the ’381 patent nor would such a person have a reasonable expectation of success in doing so. *See Takeda Pharm. Co. Ltd. v. Teva Pharm. USA, Inc.*, 542 F.Supp.2d 342, 356–59 (D. Del., 2008). HP has not provided — and cannot show — any evidence establishing that a person skilled in the art would have been motivated to modify the invention disclosed in Okada to achieve the teachings of the ‘381 patent, or that such a person would have reasonably expected to be successful in doing so. For any one of these reasons, HP’s motion should be denied.

STATEMENT OF FACTS

A. Polaroid’s ’381 Patent.

Cameras, printers, and other output devices are unable to print or display the wide range of scene variations that actually exist. *See* Joint Appendix to Polaroid’s Summary Judgment Motions (“D.I. 151”), Ex. A, col. 1, lines 26–30 (D.I. 151). As a result, brightness variations in image areas — that are, for example, either too dark due to shadows, or too bright due to excessive sunlight — are lost during the process of printing or displaying. *Id.*, lines 30–35. These details are lost because output devices such as cameras or printers compress brightness variations and detail in those areas, resulting in poor image quality. *Id.*

The invention claimed in the ’381 patent minimizes or eliminates this problem. *Id.*, col. 1, lines 46–50. The ’381 patent discloses a system and method for transforming a digital image so that the brightness of each pixel in the image is optimized. *Id.*, col. 1, lines 51–57. Because the ’381 patent operates on the image on a pixel-by-pixel basis, it is able to both lighten dark areas and darken light areas within the same image by enhancing contrast to improve the visibility of detail in an image that would otherwise be lost when the digital image is downloaded onto a computer or reproduced in hard copy. *Id.*, col. 2, lines 57–62.

The ’381 patent discloses a system to transform an image on a pixel-by-pixel basis using three steps. The first step is to calculate a local average of the pixel intensity values, A_v, near the pixel being transformed. D.I. 151, Ex. A at col. 3, lines 59–61. The second step is to use this local average, A_v, to select a unique transfer function, γ, for the pixel being transformed according to the following relationship: $\gamma=(1+C)^{(Av/M-1)}$. *See id.*, col. 4, lines 26–55. In this equation, C is a constant that is chosen based on the desired amount of correction. *Id.*, col. 4, lines 51–55. M is a number within the dynamic range of the image to be transformed, which is 0–255 for an 8-bit image. *See id.*, col. 4, lines 41–50.

The third step is to use the selected transfer function, γ, to transform the pixel according to the following relationship: $Y_{OUT} = Y_{MAX}(Y_{IN}/Y_{MAX})^{\gamma}$. *See id.*, col. 4, lines 56–65. In this equation, Y_{MAX} is the maximum value of the dynamic range used by the image (255 for an 8-bit image). *Id.*, col. 4, lines 66–68. Y_{IN} is the original intensity value of the input pixel. *See id.*, col. 4, lines 56–65. Y_{OUT} is the transformed intensity value for the input pixel. *Id.*, col. 4, line 68–col. 5, line 15. Although, the preferred embodiment in the patent uses luminance intensity values for Y_{IN} and Y_{OUT}, the patent recognizes that these intensity values can also be in color. *Id.*, col. 3, lines 25–29.

B. HP’s Accused LACE Products.

[redacted]

[redacted]

[redacted]

[redacted]

C. Prosecution Of The Application That Led To The ’381 Patent.

1. The office action and subsequent amendment.

The application that led to the ’381 patent was allowed after only one office action. *See* Joint Appendix to Claim Construction Briefs (D.I. 99). The patentees submitted original claims 1 and 8 as:

> 1. A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:
>
> means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged; and
>
> means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel.
>
> 8. A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals each signal corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:
>
> averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;
>
> selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and
>
> transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel.

[redacted]

D.I. 99 at pp. 29, 32. In the single office action, the examiner initially rejected independent claims 1 and 8[1] as obvious in view of the Okada patent under 35 U.S.C. § 103. *See id.* at pp. 47–52. Even in initially rejecting claims 1 and 8 in view of Okada, the examiner stated that ***Okada did not "identically disclose all the limitations*** as recited in" claims 1 and 8. *Id.* at p. 49, ¶ 3 (emphasis added). In addition, the examiner noted that dependent claims 3 and 10 would be allowed if rewritten to overcome the rejection under 35 U.S.C. § 112 and to include the limitations of the base claims. *Id.* at ¶ 5. The patentees submitted dependent claims 3 and 10 as follows:

> 3. The system of claim 2 wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

> 10. The method of claim 9 wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

Id. at pp. 30, 33.

The inventors amended claims 1 and 8 to incorporate all of the limitations of dependent claims 3 and 10, which the examiner indicated would be allowable. *See id.* at pp. 53–59. The

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[1] Independent claim 8 in the application issued as independent claim 7 asserted against HP in this lawsuit.

[redacted]

amended claims are rewritten below with the underlined portion indicating what was added by the amendment:

> 1. A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal <u>having a value within a determinate dynamic range of values and </u>corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:
>
> means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged; and
>
> means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel <u>wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.</u>

> 8. A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals each signal <u>having a value within a determinate dynamic range of values and </u>corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:
>
> averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;
>
> selecting one of a plurality of different transfer functions for

[redacted]

> the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and
>
> transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel <u>wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal</u>.

D.I. 99 at pp. 53–54, 56–57.

2. The Okada patent.

The Okada patent describes a system for controlling the brightness of a video signal by way of a control circuit using the global average of the scene and a single gamma function for the entire image. *See* D.I. 99 at pp. 86–100, Okada Pat., col. 4, lines 11–53. The first step that Okada describes to control brightness is to deliver the video input information signal S_I to the input of a variable correction circuit **10** and to an average picture level ("APL") detecting circuit **20** as shown below:

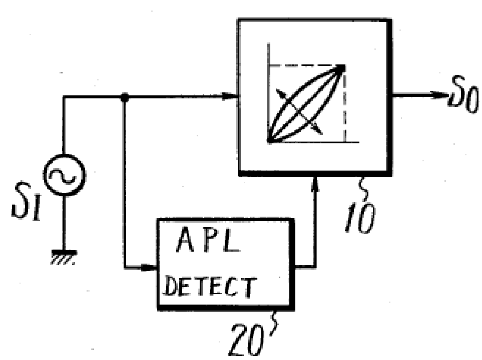

Fig. 3 of Okada

[redacted]

Id., col. 4, lines 62–64. Unlike the ’381 patent, which transforms an image on a pixel-by-pixel basis, Okada describes a system that transforms a video image by operating on the entire scene, S_I. *Id.*, col. 2, lines 29–33; *see* Ex. 3, P. Agouris Decl. at ¶ 12.

Okada describes that the APL detecting circuit **20** determines a global average brightness for the entire scene. *See* D.I. 99 at pp. 86–100, col. 4, lines 34–38; *see also* Ex. 3, P. Agouris Decl. at ¶ 14. The ’381 patent, on the other hand, calculates the local average brightness of a group of pixels surrounding the pixel being transformed rather than a global average for the entire scene. D.I. 151, Ex. A at col. 3, lines 61–67.

According to Okada, the next step for transforming a video image is for the APL detecting circuit **20** to provide the global average to the variable correction circuit **10**. D.I. 99 at pp. 86–100, col. 4, lines 65–67. The ’381 patented system, on the other hand, has an extra step here. D.I. 151, Ex. A, Fig. 1. It does not use the calculated average directly in the transformation function. *Id.* Rather, the system claimed in the ’381 patent uses the ***local*** average to select a gamma curve for the pixel being transformed. *Id.* As can be seen in Figure 1 of the ’381 patent shown below, the average A_V is never provided directly to the function that is transforming the input signal, Y_{OUT}.

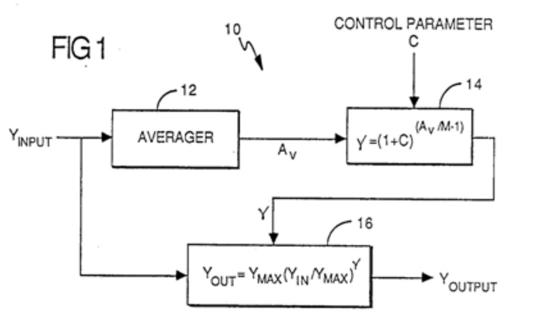

Fig. 1 of ’381 Patent

Id.

The final step is for the variable correction circuit **10** to adjust its input-output characteristic (γ) to provide an output signal S_O as a function of the detected APL. D.I. 99 at pp.86–100, col. 4, line 67–col. 5, line 4. Okada discloses that ***only one gamma*** is used to transform the entire scene. *Id.*, col. 5, lines 21–32; *see* Ex. 3, P. Agouris Decl. at ¶ 16. In contrast, the '381 patent calculates ***a value for gamma for each pixel*** in the image. D.I. 151, Ex. A at col. 4, lines 26–65.

Okada discloses that the input-output characteristic is an adjustable gamma (γ) circuit where the output signal S_O is determined according to the following function: $S_O = X^{\gamma}$, where $0 \leq X \leq 1$. D.I. 99 at pp. 86–100, col. 2, lines 49–57. Okada does not teach a specific algorithm for calculating gamma, only that gamma will be $^1/_2$ when the detected APL value is below 50%, unity when the detected APL value is at 50%, and 2 when the detected APL value is above 50%. The '381 patent discloses a specific algorithm for calculating gamma: $\gamma=(1+C)^{(Av/M-1)}$. D.I. 151, Ex. A at col. 4, line 33; Fig. 1. Gamma calculated using the algorithm taught in the '381 patent is derived from the local average A_v associated with the pixel being transformed. *Id.* As a result, gamma can change for each pixel in an image. *See* Ex. 3, P. Agouris Decl. at ¶ 16. Unlike the gamma taught in the Okada patent, gamma claimed in the '381 patent will not be constant for a range of average values. *See* D.I. 151, Ex. A, col. 4, lines 26–33.

Thus, in contrast to HP's unsupported contentions, the Okada patent differs from the claims-at-issue in the '381 patent, and from HP's LACE algorithm, in at least the following ways:

- Okada discloses a global correction system that transforms a video image by operating on ***the entire scene*** rather than on a pixel-by-pixel basis as in the '381 patent and HP's LACE algorithm;

[redacted]

- Okada calculates a ***global average*** for the entire scene whereas HP’s LACE algorithm and the system claimed in the ’381 patent only calculate a *local average* of a group of pixels near the pixel being transformed;

- Okada calculates ***one gamma value*** for the entire image whereas HP’s LACE algorithm and the ’381 patent calculate a different gamma for each pixel in an image.

- The gamma disclosed in Okada will be ***constant*** for certain ranges of the calculated global average for the scene and the system claimed in the ’381 patent and HP’s LACE algorithm[2] calculates a unique gamma for each calculated average value.

<u>ARGUMENT</u>

I. THE APPLICABLE LAW.

A. A Summary Judgment Motion Must Be Supported With More Than Attorney Argument.

The moving party is only entitled to summary judgment “if the pleadings, depositions, answers to interrogatories, and admissions, on file, together with the affidavits, if any, show that there is no genuine issue as to any material fact and that the moving party is entitled to judgment as a matter of law”. Fed.R.Civ.P. 56(c). A motion for summary judgment must be supported with more than attorney argument. *See Zenith Elec. Corp. v. PDI Commc’n Sys., Inc.*, 522 F.3d 1348, 1363–64 (Fed. Cir. 2008) (vacating district court’s grant of summary judgment because movant did not provide evidence to support its motion). Unsubstantiated attorney argument cannot support a movant’s burden on summary judgment. *Invitrogen Corp. v. Clontech Laboratories, Inc.*, 429 F.3d 1052, 1068 (Fed. Cir. 2005) (holding that defendant did not meet its summary judgment burden in relying solely on attorney argument to explain the meaning of technical evidence). There must be sufficient substance, other than attorney argument, to conclusively establish that there is not a single material fact requiring a trial.

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2 Although the exponent in HP’s LACE source code is referred to as “a”, the parties agree that “a” and “γ” operate in the same way. *See* D.I. 137 at p. 19, ¶ 35.

[redacted]

B. Prosecution History Estoppel Does Not Apply If The Alleged Equivalent Falls Outside The Scope Of Subject Matter Surrendered Or If The Presumption Is Properly Rebutted.

Prosecution history estoppel is a "flexible" doctrine, not a "rigid" one. *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.,* 535 U.S. 722, 738 (2002). Prosecution history estoppel is not absolute when a patentee makes a narrowing amendment during prosecution, even where the amendment was made for a substantial reason relating to patentability. *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.,* 344 F.3d 1359, 1366–67 (Fed. Cir. 2003). Prosecution history estoppel does not apply when the alleged equivalent falls outside of the scope of the subject matter surrendered by the patentee. *Id.* at 1367. In addition, prosecution history estoppel may be rebutted by demonstrating: "(1) 'the alleged equivalent would have been unforeseeable at the time ... the narrowing amendment' was made; (2) 'the rationale underlying the narrowing amendment bore no more than a tangential relation to the equivalent' at issue; and (3) 'there was "some other reason" suggesting that the patentee could not reasonably have been expected to have described the alleged equivalent.'" *Id.* at 1368.

II. HP HAS NOT ESTABLISHED — AND CANNOT SHOW — AN ABSENCE OF ANY GENUINE ISSUE OF MATERIAL FACT FOR POLAROID'S INFRINGEMENT CLAIM.

A. HP's Motion Must Fail Because HP Has Not Supported Its Non-Infringement Contentions With Any Evidence.

HP's sole support for its arguments that it does not infringe the asserted claims is unsubstantiated attorney argument. Unsubstantiated attorney argument is not sufficient to prove that HP is entitled to judgment as a matter of law. *See Invitrogen*, 429 F.3d at 1068 (holding that a movant cannot meet its burden that it is entitled to judgment as a matter of law with attorney argument alone); *Glaverbel Societe Anonyme*, 45 F.3d at 1562 holding that attorney argument was insufficient to show that issues require trial). The court in *Invitrogen* held that a genuine

[redacted]

issue of material fact existed as to whether a researcher conceived of invention before critical date, precluding summary judgment on conception issue in infringement lawsuit. *Invitrogen*, 429 F.3d at 1068. The court held that the defendant failed to provide the court with expert testimony that properly explained technical entries found in laboratory notebooks and that the "extensive attorney argument" regarding the notebook entries was insufficient to meet the defendant's burden on summary judgment:

> Although [defendant] responds to that evidentiary problem with extensive attorney argument regarding multiple notebook entries, the argument is insufficient . . . . Unsubstantiated attorney argument regarding the meaning of technical evidence is no substitute for competent, substantiated expert testimony. It does not, and cannot, support [defendant's] burden on summary judgment.

Id. (internal citations omitted).

Similarly, HP supports its motion for summary judgment with nothing more than unsubstantiated attorney argument. HP argues that its accused products do not literally infringe Claims 7–9 because they do not "include a ratio of any kind." *See* D.I. 137 at p. 25–26. HP, however, does not cite to a single piece of evidence to support this argument. *See id.* HP also argues without evidentiary support that "the doctrine of equivalents is not available to Polaroid" because the doctrine of prosecution history estoppel applies. *See id.* at pp. 26, 27. For example, HP makes the following arguments to support its position but fails to cite to a single piece of evidence:

- "It is beyond dispute that Polaroid's amendment narrowed claim 7 by adding the ratio limitation." (*Id.* at p. 27)
- "It is equally clear that the amendment was made for a substantial reason relating to patentability." (*Id.*)
- "[This case] does not involve previously non-existent technology." (*Id.* at p. 28)

[redacted]

- "[T]his is not a case where the rationale underlying the amendment was no more tangentially related to the alleged equivalent." (*Id*.)

HP also argues that its accused products do not infringe Claims 1–3 because they do not contain "any ratio." *See id.* at p. 33. As with its arguments with respect to Claims 7–9, HP fails to provide any evidence to support its position. For example, HP argues that the [t]he function portion of this limitation is not satisfied" without citing to a single piece of evidence. *See* D.I. 137 at pp. 33–34. HP also fails to provide any evidence to support its contention that "HP does not use a structure that is the same as, or the equivalent of, the structure disclosed in the '381 patent." *Id.* at pp. 35–36.

Unsubstantiated attorney argument is not enough for summary judgment, and for this reason alone, HP's motion should be denied.

B. Even Assuming That HP Had Provided Appropriate Support, HP's Motion Still Must Fail Because There Is Ample Evidence That HP Infringes The Asserted Claims And At A Minimum, There Are Issues Of Material Fact.

HP's sole argument that it is entitled to summary judgment of non-infringement is because its accused products do not satisfy the ratio limitation found in the asserted claims. *See* D.I. 137 at p. 21. Claim 1 contains a preamble and two means-plus-function claim elements. D.I. 151, Ex. A at col. 7, line 61–col. 8, line 20. The claimed ratio is found in the second means-plus-function claim element — the "means for selecting and transforming". *Id.* at col. 8, lines 16–21. Claim 7 is a method claim with a preamble and three claim elements. *Id.* at col. 9, line 42–col. 10, line 2. The claimed ratio is found in the third claim element. *Id.* at col. 9, line 68–col. 10, line 2.

1. HP's LACE algorithm performs the claimed function of the "means for selecting and transforming" element in Claim 1.

Polaroid and HP have competing constructions for the function of the "means for selecting and transforming" claim element as shown below:

[redacted]

Polaroid's Construction	**HP's Construction**
Function: selecting one of a plurality of different functions that transform an input signal for the signal providing pixel information, such as color, luminance, or chrominance value for each of the succeeding pixels in a manner whereby each function that transforms an input signal is selected as a function of the signal providing pixel information, such as color, luminance, or chrominance value for one pixel and the signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value for the select plurality of pixels containing said one pixel and for subsequently transforming the signal providing pixel information, such as color, luminance, or chrominance value corresponding to each pixel by the function that transforms an input signal selected for that pixel wherein said selecting and transforming means further operates to select said function that transforms an input signal as a function of ***the ratio of that calculated intermediate value over a value that lies within the range of possible values*** such that the ratio increases in correspondence with the increase in the value of the signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value.	**Function:** selecting a transfer function for each incoming pixel based on the pixel value and its corresponding average electronic information signal, and ***based on the result of dividing a first existing data value representing the average electronic information signal by a second existing data value representing the dynamic range of the average electronic information signals.**** ***HP contends that "dynamic range of the electronic information signals" should be construed as "an integer representing the number of possible pixel values; for an 8-bit system, 256". It appears from HP's brief that it contends that this definition also applies to "the dynamic range of the *average* electronic information signals" found in its construction of the function of this claim element.

D.I. 151, Ex. D at pp. 4–5 (emphasis added).

In contrast to HP's unsupported attorney argument, there is expert testimony and facts in the record establishing that under Polaroid's proposed construction, HP's accused products perform the identical function of this claim element with structure that is the same as, or structurally equivalent to, that claimed in the patent. Expert testimony and facts in the record also establish that under HP's proposed claim construction, HP's accused products perform the equivalent function of this claim element with structure that is equivalent to that claimed in the patent.

[redacted]

None of HP's three contentions for why its accused products do not satisfy the function portion of the "means for selecting and transforming" claim element is supported or supportable. *See* D.I. 137 at pp. 33–34.

(i) HP's accused products select a transfer function as a function of a ratio.

HP's unsupported argument that the LACE algorithm does not select a transfer function as a function of any ratio is in direct contrast to the facts. *See* D.I. 137 at p. 33. [redacted]

In contrast to HP's unsupportable theory, there is no question that a number in decimal form is a ratio. *See* Ex. 4, P. Agouris Dep. Tr. at p. 79, line 22–p. 83, line 23; *see also* "the decimal 0.1 = $\frac{1}{10}$. . ." The American Heritage® Dictionary of the English Language, Fourth Edition, Houghton Mifflin Company, 2004. 31 May. 2008. <Dictionary.com http://dictionary.reference.com/browse/decimal>. A basic math text explains that "$^1/_2$ is a common fraction. 50% is a percent. And .50 is a decimal. They are three different ways to show the same thing. They are three different kinds of fractions." Ex. 5, Rose Lock and Evelyn

[redacted]

Morabe-Murphy, DECIMALS AND PERCENTS 71 (Janus Book Publishers, Inc. 1987). This same text explains that "a ratio *is* a fraction". *Id.* at p. 53 (emphasis in original). HP's algorithm has a ratio of a local average to a constant just like the claimed ratio. Thus, HP's LACE algorithm selects a transfer function as a function of a ratio and HP's first argument fails.

(ii) Prosecution history estoppel does not apply because HP's accused products perform the identical function under Polaroid's claim construction, and the equivalent function under HP's claim construction is not within the scope of any purported surrender.

Polaroid is not barred by the doctrine of prosecution history estoppel from arguing that the LACE algorithm performs an equivalent function as HP contends. *See* D.I. 137 at p. 33. Expert testimony and the facts in the record demonstrate that HP's accused products perform the identical function of the "means for selecting and transforming" claim element under Polaroid's claim construction. *See* D.I. 151, Ex. B at pp. 24–37. HP misstates the construction of the function for the "means for selecting and transforming" claim element under Polaroid's proposed claim construction. *See* D.I. 137 at pp. 32–33. Polaroid did not construe the ratio to require "the use of 'the' dynamic range of the electronic information signals — 256 — as one component of that ratio" as HP contends. *See* D.I. 137 at p. 32. Rather, Polaroid construes the phrase "the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals" as "the ratio of that calculated intermediate value over a value that lies within a range of possible values." D.I. 151, Ex. D at pp. 4–5. As explained in Polaroid's opening claim construction brief, Polaroid's construction is consistent with the intrinsic evidence. *See* Pol.'s Op. Claim Construction Brief at pp. 22–29 (D.I. 100). [redacted] An 8-bit image has a dynamic range of values ranging from 0 to 255. D.I. 151, Ex. A at col. 3, lines 46–48. Thus, 256 cannot be "a value that lies within a range of possible values."

[redacted]

HP's accused products perform the identical function of the "means for selecting and transforming" claim element under Polaroid's proposed construction. [redacted]

The Federal Circuit has reversed summary judgment of non-infringement where an accused algorithm was "mathematically equivalent" to an algorithm claimed in the patent. *See*,

[redacted]

e.g., *Transonic Sys., Inc. v. Non-Invasive Medical Techs. Corp.*, 143 Fed.Appx. 320, 329 (Fed. Cir. 2005). In *Transonic Systems*, the trial court granted summary judgment of non-infringement because the accused product did not contain the specific equation claimed in the patent. *Id.* The Federal Circuit reversed and remanded holding that a reasonable fact-finder could find that the accused method literally infringed the asserted claims by using an equation that was mathematically equivalent to the claimed equation. *Id.* at 323, 329.

Similarly, HP's accused products use an algorithm that is mathematically equivalent to the algorithm claimed in the '381 patent. Because a reasonable fact finder could find - and must find under basic mathematical principles - that the accused algorithm selects a transfer function as a function of a ratio, HP's argument that it does not perform the identical function of the "means for selecting and transforming" claim element under Polaroid's construction fails.

The doctrine of prosecution history estoppel does not preclude Polaroid from arguing that HP's accused products include the equivalent function of the "means for selecting and transforming" claim element. Prosecution history estoppel only applies to the scope of equivalents between the original claim and the claim as amended. *Festo*, 344 F.3d at 1367. In this case, Polaroid amended the independent claims to add the limitation of a ratio. *See* D.I. 99 at pp. 53–54, 56–57. HP contends that the scope of the subject matter surrendered is algorithms without a ratio of any kind. *See* D.I. 137 at pp. 27–28. The accused equivalent in this case, however, is an algorithm ***with*** a ratio. Thus, the proper equivalency determination here is whether the algorithm with a ratio having a denominator of 192 — is equivalent to an algorithm ratio having a denominator of 256. *See* D.I. 151, Ex. B at pp. 42–46. Because the alleged equivalent falls outside the scope of the purported surrendered claim scope, the doctrine of prosecution history estoppel does not apply. *Festo*, 344 F.3d at 1367.

[redacted]

Even if the equivalent were within the scope of subject matter surrendered, Polaroid can rebut the application of prosecution history estoppel because the narrowing amendment bore no more than a tangential relation (if any) to the equivalent in question. *See Primos, Inc. v. Hunter's Specialties, Inc.*, 451 F.3d 841, 849 (Fed. Cir. 2006). The court in *Primos* analyzed whether the patentee was estopped from arguing that "a plate extending over a membrane" was equivalent to a "dome extending over the membrane". *Id.* at 845–46. During prosecution, the patentee narrowed the claim to include only plates that are "differentially spaced" above the membrane. *Id.* at 849. The Federal Circuit, noting that "the territory surrendered by the 'differentially spaced' amendment comprise[d] plates that are not differentially spaced above the membrane," held that the differentially-spaced dome of the accused device was only tangentially related to the rationale underlying the amendment. *Id.* at 849.

Similarly, the expression of the ratio in HP's algorithm is only tangentially related to the rationale underlying Polaroid's amendment to the asserted claims of the '381 patent. During prosecution, Polaroid narrowed the independent claims to include algorithms with a ratio that determines which curve is selected based on a local intensity average and a constant. *See* D.I. 99 at pp. 53–54, 56–57. According to HP, the territory surrendered by the "ratio" amendment comprised algorithms that do not have a ratio. *See* D.I. 137 at pp. 27–28. Thus, under *Primos*, Polaroid is not barred by prosecution history estoppel from arguing that the ratio contained in HP's accused products is equivalent to the claimed ratio because the alleged equivalent is only tangentially related (if at all) to the rationale underlying the amendment.

(iii) HP's accused products perform the equivalent function under HP's claim construction.

HP's argument that the denominator of the ratio claimed in the '381 patent — "the dynamic range of the electronic information signals" — should be construed to equal 256 is

[redacted]

contrary to the plain meaning of the term "dynamic range", the intrinsic record, and to the position HP has taken with respect to other elements found in the claim.

HP's proposed construction of "256" is contrary to the plain meaning of the phrase "dynamic range". The term "range" means "the extent to which or the limits between which variation is possible." Dictionary.com Unabridged (v 1.1). Random House, Inc. http://dictionary.reference.com/browse/range (accessed: June 02, 2008). The term "dynamic range" similarly means "the extent to which or the limits between which the variation in intensity levels is possible". *See* D.I. 151, Ex. A at col. 3, lines 47–49; Ex. 4, P. Agouris Dep. Tr. at p. 16, lines 11–14. Thus, "dynamic range" cannot be limited to one value. And, HP's construction of the phrase "dynamic range" must be rejected for this reason alone.

HP's proposed construction of "256" is contrary to the intrinsic evidence. HP concedes that the intrinsic evidence supports a construction in which the denominator of the ratio is not 256, but any value within the dynamic range of the image. In its brief in support of its motion for summary judgment of non-infringement, HP acknowledges that the only ratio that the '381 patent teaches is $\frac{Av}{M}$. *See* D.I. 137 at p. 26. HP explains over and over that the patent teaches that M can take any value within the dynamic range, which is 0 to 255 for an 8-bit image. *See id.* at pp. 4, 7, 13–14, 26. HP has not, and cannot, identify a single instance where the patent teaches that it is possible for the denominator of the ratio, "M", to take on a value larger than 255 in an 8-bit space. Thus, HP's proposed construction for "dynamic range" must be rejected for this independent reason.

HP's proposed construction that the denominator of the ratio, "M", should be limited to a value of 256 in the claimed function contradicts its position with respect to the structure that it claims is associated with that function. In its proposed construction of the structure associated

[redacted]

with the "means for selecting and transforming", HP contends that M should be construed as a value that "equals one half of the dynamic range." *See* D.I. 151, Ex. D at p. 4. For an 8-bit system, this means that HP contends that M should be equal to 128. *See id.*, Ex. A, col. 4, lines 34–39. This position contradicts HP's construction that M should be limited to 256 when construing the function portion of the means-plus-function claim element. Thus, HP's proposed construction for "dynamic range" must be rejected for this additional, independent reason.

Even assuming *arguendo* that M were properly construed to be 256 as HP contends — which is not correct — HP performs the function of the "means for selecting and transforming" claim element under the doctrine of equivalents. *See* D.I. 151, Ex. B at p. 42. [redacted] And, as explained above, Polaroid is not precluded by the doctrine of prosecution history estoppel from arguing that HP's accused products perform the claimed the function under the doctrine of equivalents.

At a minimum, there are multiple genuine issues of material fact, and HP's Motion must be denied on the basis of any one of them.

2. HP's LACE algorithm contains the corresponding structure for "the means for selecting and transforming" element of Claim 1.

Polaroid's and HP's competing constructions for the structure for the "means for selecting and transforming" claim element are shown below:

Polaroid's Construction	**HP's Construction**
Structure: $Y_{OUT} = Y_{MAX}*(Y_{IN}/Y_{MAX})^{\gamma}$, where $\gamma=(1+C)^{(Av/M-1)}$ and equivalents thereof.	**Structure:** a gamma determining circuit 14 containing a multiplier circuit 18, a combining circuit 20, a second combiner circuit 22, a log circuit 24, a multiplier circuit 26 and a antilogarithmic

[redacted]

	determining circuit 28 – all arranged according to Fig 4, which computes gamma based on the formula $\gamma = (1 + C)^{(A_v/M-1)}$, where A_v is average luminance of the input, C is a constant and M equals one half of the dynamic range. and the transfer function imposing circuit 16 containing a logarithm determining circuit 30, a combiner circuit 32, a multiplier circuit 34, a second combiner circuit 36 and an antilogarithm determining circuit 38 – all arranged according to Fig 4, which computes an output luminance: $Y_{Out} = Y_{Max}(Y_{In}/Y_{Max})^{\gamma}$, where Y_{Out} is the output luminance value, Y_{Max} is the maximum value in the dynamic range (255), Y_{In} is the input pixel value, and γ is the "means for selecting a transfer function" and equivalents.

D.I. 151, Ex. D at pp. 4–5. HP's accused products utilize the identical structure associated with the claimed function or one that is structurally equivalent regardless of which claim construction is adopted. *See id.*, Ex. B at pp. 28–30, 31–34, 36–37, 44–46.

HP argues that its accused products do not contain the structure required under Polaroid's claim construction because "an algorithm is not structure." *See* D.I. 137 at pp. 35, 36. HP does not — and cannot — cite to a single fact in the record to support this argument, and HP's Motion with respect to Polaroid's claim construction must be denied for this reason alone.

In contrast to HP's contention, this Court has explicitly held that an algorithm is a sufficient structure for a means-plus-function claim element. *See, e.g.*, *McKesson Info. Solutions v. Trizetto Group, Inc.*, No. Civ. 04-1258-SLR, 2006 WL 891048, *1, 2 (April 5, 2006). In *McKesson*, this Court held that the structure for performing the function of a means-plus-function claim element was limited to the disclosed algorithm in the patent specification. *Id.* at *1. The Court determined that the block diagrams in the patent taught that the functions could be performed by software even though the patentee acknowledged that there was no software

[redacted]

available at the time of the patent to carry out the claimed function. *Id.* n. 22. Relying upon *WMS Gaming, Inc. v. Int'l Game Tech.*, 184 F.3d 1339 (Fed. Cir. 1999), this Court held that the structure was limited to the algorithms disclosed in the patent and their equivalents. *McKesson*, 2006 WL 891048 at *1.

HP's cited case law does not change this reality. None of the cases upon which HP relies address whether algorithms are an appropriate structure for a means-plus-function claim. Instead, the court in *Ballard Medical Prods. v. Allegiance Healthcare Corp.* analyzed means-plus-function claim limitations directed to specific valve structures. *Ballard Medical Prods.*, 268 F.3d 1352, 1361–62 (Fed. Cir. 2001). The court in *Signtech USA Limited v. Vutek, Inc.* analyzed means-plus-function claim limitations directed to ink delivery systems. *Signtech*, 174 F.3d 1352, 1357–58 (Fed. Cir. 1999). The court in *Mas-Hamilton Group v. LaGard, Inc.* analyzed means-plus-function claim limitations directed to a mechanical lever. *Mas-Hamilton*, 156 F.3d 1206, 1212–13 (Fed. Cir. 1998). And, the court in *Faroudja Labs., Inc. v. Dwin Elecs., Inc.* analyzed means-plus-function claim limitations directed to electrical components. *Faroudja*, 76 F. Supp. 2d 999, 1012 (N.D. Cal. 1999). Indeed, *Faroudja* supports Polaroid's claim construction and not HP's. The court in *Faroudja* recognized that "a means-plus-function claim is not limited to the most detailed description of the structure disclosed in the patent" when alternative embodiments are disclosed. *Id.* at 1011 (quoting *Serrano v. Telular Corp.*, 111 F.3d 1578 (Fed. Cir. 1997)).

The inventors of the '381 patent disclosed a specific algorithm for performing the claimed function of the "means for selecting and transforming" claim element. *See* D.I. 151, Ex. A at col. 4, lines 26–col. 5, line 3. This is the algorithm that Polaroid contends is the structure for the "means for selecting and transforming" claim element. *See* D.I. 151, Ex. D at p. 5.

[redacted]

HP's LACE products contains this algorithm. [redacted] Because a decimal is the same as a ratio, HP's accused products literally infringe this claim element under Polaroid's construction. Even assuming that a decimal is not identical to a ratio but only structurally equivalent to a ratio, then HP's accused products still literally infringe this claim element under Polaroid's construction. In either case, because HP's accused products perform an equivalent function under HP's proposed claim construction, they infringe this claim element under the doctrine of equivalents.

HP contends that the structure associated with this means-plus-function claim element is the circuit diagram shown in Figure 4 of the patent, even though this is just one embodiment described in the patent. *See* D.I. 137 at pp. 34–36. In any event, HP's use of source code to implement the algorithms is structurally equivalent to using the hardwired circuits shown in Figure 4. *See* D.I. 151, Ex. B at pp. 45–46. Implementing a system using software serves substantially the same function as implementing a circuit using hardwired circuits. *Id.* at p. 45; *see also Interactive Pictures Corp. v. Infinite Pictures, Inc.*, 274 F.3d 1371, 1383 (Fed. Cir. 2001) (holding that hardware and software implementations of a component of an invention are interchangeable substitutes even though such a substitution would require ancillary changes in affected circuitry and packaging); *Overhead Door Corp. v. Chamberlain Group, Inc.*, 194 F.3d

[redacted]

1261, 1269–70 (Fed. Cir. 1999) (reversing summary judgment of non-infringement because there was a genuine issue of material fact that a software implementation of a hardware switch were interchangeable substitutes). In both cases, the function is to accomplish specific mathematical operations. *Id.*

In addition, one implements algorithms in circuitry in substantially the same way as one implements algorithms in software. *Id.* In circuitry, one relies upon logarithm determining circuits, combining circuits, multiplication circuits, and an antilogarithm combining circuit to perform the necessary mathematical operations. *See* D.I. 151, Ex. A, Fig. 4. At the time of the patent, these circuits were an easy and convenient way to implement algorithms. *Id.*, col. 7, lines 33–41. When using software, one relies on source code to accomplish the same mathematical operation. *See* D.I. 151, Ex. B at p. 45. It is generally recognized that implementing algorithms in software is substantially the same as implementing algorithms in circuitry. *See id.* The same result is accomplished by implementing algorithms in circuitry or in software. *See id.* Thus, HP's LACE algorithm is structurally equivalent to the hardwired circuits that HP contends is required by the "means for selecting and transforming" claim element.

Because HP's accused products perform an equivalent function under HP's proposed claim construction, they infringe this claim element under the doctrine of equivalents.

HP argues that it does not infringe Claims 2 and 3 for the same reasons it does not infringe Claim 1. *See* D.I. 137 at p. 37. Because HP's arguments with respect to Claim 1 lack

[redacted]

merit, its motion for summary judgment of non-infringement of Claims 2 and 3 should also be denied.[3]

3. There Are Genuine Issues Of Material Fact Regarding Claims 7–9.

HP's only argument that it is entitled to judgment as a matter of law that its accused products do not infringe Claim 7 is that its accused products do not include the claimed ratio, $\frac{Av}{M}$. *See* D.I. 137 at p. 28. As explained with respect to Claims 1–3, this argument lacks merit. HP's LACE algorithm contains this ratio under both Polaroid's and HP's claim constructions. *See* D.I. 151, Ex. B at p. 67; 71–72. [redacted]

HP's argument that Polaroid's infringement contention vitiates the ratio requirement in the claim is equally unavailing. *See id.* at pp. 28–30. Polaroid's expert, Dr. Agouris, did not opine that any number can be represented as a ratio as HP contends. *See id.* (mischaracterizing Dr. Agouris's opinion as "any number can be represented as a ratio of any two other numbers.") Rather, Dr. Agouris opined that "strength" used in HP's algorithm could be represented as a

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3 Polaroid provides additional evidence as to why HP's accused products infringe Claims 2 and 3 under Polaroid's claim construction in its Brief in Support of Summary Judgment of Infringement (D.I. 142).

[redacted]

fraction because "strength" was a ratio represented as a decimal. *See* D.I. 151, Ex. B at p. 27; *see also* Ex. 4, P. Agouris dep., p. 88, lines 2–4. Moreover, Dr. Agouris did not "create[] a ratio" by expressing HP's algorithm to include a fraction instead of a decimal. *See* D.I. 137 at p. 28; Ex. 4, P. Agouris dep., p. 88, lines 5–7. Fractions and decimals are the same thing — they are both ratios. Ex. 5, Lock and Morabe-Murphy, DECIMALS AND PERCENTS at pp. 53, 71.

In addition, as explained with respect to Claims 1–3, [redacted] And, HP does not offer any support, other than impermissible attorney argument, in defense. *See*, *e.g.*, D.I. 137 at p. 20–21 (arguing that the LACE algorithm does not include "a ratio of any type" with no evidentiary support); *id.* (alleging that it is an "undisputed fact that the LACE algorithm does not use a ratio of any type with no support); p. 26 (arguing that "the LACE algorithm does not include a ratio of any kind" with no support); p. 33 (arguing that the LACE algorithm does not perform the claimed function of the "means for selecting and transforming" element as a function of "any ratio" with no support).

HP's argument that it does not infringe Claims 8 and 9 rely on its arguments made to defend against infringement of Claim 7. *See* D.I. 137 at pp. 29–30. Because HP's arguments with respect to Claim 7 lack merit, its motion for summary judgment of non-infringement of Claims 8 and 9 should also be denied.

[redacted]

III. HP HAS NOT ESTABLISHED — AND CANNOT SHOW — AN ABSENCE OF ANY GENUINE ISSUE OF MATERIAL FACT ON HP'S INVALIDITY CLAIM BASED ON THE OKADA REFERENCE.

Just as with its non-infringement position, HP moved for summary judgment of patent invalidity with no support other than attorney argument.[4] *See* D.I. 137 at pp. 37–39. Because unsubstantiated attorney argument is not sufficient to meet the burden of summary judgment, HP's motion should be denied. *See Invitrogen*, 429 F.3d at 1068 (holding that a movant cannot meet its summary judgment burden with attorney argument alone). Even if HP had provided support for its motion for summary judgment, it could not prove that the Okada reference rendered the asserted claims of the '381 patent invalid by clear and convincing evidence, particularly in light of the fact that the Okada reference was before the Examiner during prosecution. *See e.g., Hewlett-Packard Co. v. Bausch & Lomb Inc.*, 909 F.2d 1464, 1467 (Fed. Cir. 1990) (affirming validity of patent claim when claim "was specifically allowed by the Patent or Trademark Office (PTO) over the [allegedly invalidating] patent.").

A. HP's Motion Must Fail Because Okada Does Not Anticipate The Asserted Claims, And At A Minimum, There Are Issues Of Material Fact.

"Anticipation *requires the presence in a single prior art disclosure of all elements of a claimed invention* ***arranged as in the claim.***" *Soundscriber Corp. v. United States,* 360 F 2d. 954, 960 (Ct. Cl. 1966) (**emphasis added**). The Okada reference does not anticipate the asserted claims of the '381 patent because it does not teach each and every element of the asserted claims either expressly or inherently. *See Commissariat a L'Energie Atomique v. Samsung Electronics*

[4] The arguments that HP makes with respect to the Okada reference are similar to those its expert, Dr. Rangayyan, made in his supplemental expert report. Polaroid, however, has moved to preclude HP's reliance on Dr. Rangayyan's supplemental expert report because the supplemental report was belatedly produced in violation of the Scheduling Order for this case. *See* Pol.'s Mot. to Preclude HP From Relying On Untimely Produced Discovery (D.I. 172).

[redacted]

Co., 524 F.Supp.2d 546, 551–52 (D. Del. 2007) (denying summary judgment where genuine issue of material fact existed as to whether prior art anticipated claim limitations); *see also* Ex. 3, P. Agouris Decl. at ¶ 7.

The Okada reference was before the Examiner during prosecution of the application that led to the '381 patent. *See* D.I. 99 at p. 51. After reviewing Okada, the examiner stated that Okada did not "identically disclose all the limitations as recited in" claims 1 and 8. *Id.* at p. 49, ¶ 3. The examiner made this statement prior to any amendment by the patentee adding the requirement of a ratio to the independent claims. *Id.*

Consistent with the examiner's statement, the system disclosed in Okada differs fundamentally from the system claimed in the '381 patent (and from HP's LACE products) because Okada's system is a global correction method. Okada transforms an image using measures taken from the entire image rather than on a pixel-by-pixel basis. [redacted] and the system claimed in the '381 patent transform an image locally, by transforming each pixel in the image in a sequential manner until the entire image is transformed.

Okada's system differs from HP's LACE algorithm and the system claimed in the '381 patent in at least three ways. *First*, Okada teaches that the transformation of the video image must occur by analyzing the entire image and not each pixel of an image. *See* Ex. 3, P. Agouris Decl. at ¶ 17. [redacted] and the '381 patent, on the other hand, transform images on a pixel-by-pixel basis. *Id.* *Second*, Okada only calculates a global average for the entire scene. *See id* at ¶¶ 14, 17. In contrast, [redacted] and the system claimed in the '381 patent only calculate a local average of a group of pixels near the pixel being transformed. *Id.* *Third*, Okada calculates one gamma value for the entire image. *See id.* at ¶ 16. In contrast, [redacted] and the '381 patent calculate a different gamma for each pixel in an image.

[redacted]

In addition to these fundamental differences, Okada does not disclose a transfer function that reads on the transfer function disclosed in the ’381 patent. *See* Ex. 3, P. Agouris Decl. at ¶ 19. The transfer function disclosed in Okada is: $S_O = X^\gamma$, where $0 \leq X \leq 1$. D.I. 99 at pp. 86–100, col. 2, lines 49–57. The transfer function disclosed in the ’381 patent is: $Y_{OUT} = Y_{MAX}*(Y_{IN}/Y_{MAX})^\gamma$. The Okada transfer function does not disclose each element of the ’381 patent’s transfer function either expressly or inherently. *See* P. Agouris Decl. at ¶¶ 7, 19. Even if Y_{IN}/Y_{MAX} of the ’381 patent did vary between 0 and 1 like X in Okada, Y_{IN}/Y_{MAX} is multiplied by the maximum value in the dynamic range after being raised to the power of gamma. Okada does not disclose these mathematical operations.

Okada also does not teach a specific algorithm for calculating gamma, only that gamma will be $^1/_2$ when the detected APL value is below 50%, unity when the detected APL value is at 50%, and 2 when the detected APL value is above 50%. D.I. 99 at pp. 86–100, col. 5, lines 21–32. The ’381 patent, on the other hand, teaches that $\gamma=(1+C)^{(Av/M-1)}$. *See* D.I. 151, Ex. A at col. 4, line 32. Gamma in the ’381 patent could change for every pixel in an image. *See* id. at col. 4, lines 26–33. Okada does not teach each and every element of the asserted claims. At a minimum, there are genuine issues of material fact, and HP’s motion for summary judgment of invalidity should be denied.

B. HP’s Motion Must Fail Because Okada Does Not Render The Asserted Claims Obvious, And At A Minimum, There Are Issues Of Material Fact.

HP has not satisfied — and cannot fulfill — its burden of conclusively establishing that one of ordinary skill in the art would have been motivated to modify the Okada reference to teach the elements of the ’381 patent’s system and that such a person would have had a reasonable expectation of success in doing so. *See Takeda Pharm. Co. Ltd. v. Teva Pharm. USA, Inc.*, 542 F. Supp. 2d 342, 356–59 (D. Del. 2008) (holding that a defendant must prove

[redacted]

motivation and a reasonable expectation of success). Far from supporting its burden on summary judgment, ***HP did not even address either of these required prongs***, and its summary judgment motion must be denied.

The examiner allowed the ’381 patent over the Okada reference. HP does not argue that the examiner made a mistake in allowing Okada. Rather, HP argues that Okada invalidates the asserted claims if A_v/M from the ’381 patent is substituted in for gamma in Okada. *See* D.I. 137 at p. 38, n. 7. HP neither provides any evidence that one of skill in the art would be motivated to make this substitution nor provides any evidence that such a person would have a reasonable expectation of success in doing so.

There are no teachings in Okada that would suggest that gamma could be calculated using the signal from the APL detecting circuit **20** and dividing by a value that lies within the dynamic range of the video image. *See* Ex. 3, P. Agouris Decl. at ¶ 18. To the contrary, Okada repeatedly refers to the signal for the APL detecting circuit 20 as a percentage. *See*, *e.g.*, D.I. 99 at pp. 86–100, col. 5, lines 21–28. Okada does not even mention the dynamic range of the video image, or how the dynamic range could possibly be used to impact the transformation process. *See id*. There is no evidence — and HP does not even attempt to establish any — that one of skill in the art would have a reasonable expectation of success of substituting A_v/M for gamma in Okada in an effort to obtain the ratio A_v/M claimed in the ’381 patent. *Id.* at ¶¶ 18–19.

HP does not submit any support for its contention that Okada’s transfer function renders the asserted claims of the ’381 patent obvious, even after arbitrarily substituting the claimed ratio A_v/M for gamma. *See* D.I. 137 at pp. 38–39. Okada’s transfer function after HP’s arbitrary substitution is:

$$S_O = X^{(Av/M)}$$

[redacted]

Id. at p. 38, n. 7. The transfer function disclosed in the ’381 patent is:

$$Y_{OUT} = Y_{MAX}*(Y_{IN}/Y_{MAX})^{(1+C)^{(Av/M-1)}}.$$

D.I. 151, Ex. A at col. 4, lines 33, 64. Okada does not even suggest that one of skill in the art would be motivated to substitute the algorithm $Y_{MAX}*(Y_{IN}/Y_{MAX})$ for the value X. To the contrary, Okada teaches away from such a substitution, disclosing that X will always fall between 0 and 1. D.I. 99 at pp. 86–100, col. 2, lines 53–54. $Y_{MAX}*(Y_{IN}/Y_{MAX})$, on the other hand, will vary between 0 and the maximum intensity value for the dynamic range of the image, which is 255 for an 8-bit image. D.I. 151, Ex. A at col. 3, lines 47–49.

HP also misconstrues Dr. Agouris’s opinion that HP’s references are cumulative over the references already before the examiner during prosecution of the application that led to the ’381 patent. *See* D.I. 137 at p. 39. In her rebuttal expert report, Dr. Agouris explained that the references that HP disclosed in Dr. Rangayyan’s expert report were cumulative over the Okada reference because Dr. Rangayyan’s references did not disclose a ratio of A_v/M. *See* D.I. 151, Ex. C at pp. 30–32. Dr. Agouris did not opine that Okada taught the use of the ratio and/or exponent A_v/M in the same way as taught in the ’381 patent. *Id.*; *see also* Ex. 3, P. Agouris Decl. at ¶¶ 6–7. Rather, Dr. Agouris was referring to the value “X” disclosed in Okada when she said that Okada taught “[a] function that transforms an input signal where the function is selected as a ratio of the average over a value within the dynamic range”. *Id.* at ¶ 8. Okada teaches that X is derived from the APL detecting circuit **20** in conjunction with the input signal S_I. D.I. 99 at pp. 86–100, Fig. 3. Because Okada teaches that X is normalized so that it falls between 0 and 1, the signal from the APL detecting circuit **20** must be divided by the maximum value that the APL circuit can take, which is a value within the dynamic range of the video image. *See* Ex. 3, P. Agouris Decl. at ¶ 15.

[redacted]

Although not Polaroid's burden here, the evidence shows that one of skill in the art would not be motivated to revise the teachings of Okada to reach the invention claimed in the asserted claims and would not have any reasonable expectation of success in doing so. *See id.* at ¶¶ 18–19. At a minimum, HP has not established the absence of any genuine issue of fact, and HP's motion for summary judgment of invalidity should be denied.

CONCLUSION

HP's only argument in support of non-infringement is that its LACE algorithm does not contain the claimed ratio. With respect to Claims 1–3, the undisputed facts prove that HP's LACE algorithm contains structure satisfying the claimed ratio element literally under Polaroid's claim construction or equivalently under HP's claim construction. With respect to Claims 7–9, the undisputed facts prove that HP's LACE algorithm literally contains the claimed ratio requirement under either party's claim construction. Also, HP failed to meet its burden that the Okada reference either anticipated the asserted claims or rendered them obvious with clear and convincing evidence. Therefore, Polaroid requests that the Court deny HP's motion for summary judgment of non-infringement, or in the alternative, patent invalidity.

* * *

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CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that on June 12, 2008, I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to the following:

William J. Marsden, Jr.
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I also certify that copies were caused to be served on June 12, 2008 upon the following in the manner indicated:

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EXHIBIT 1

REDACTED

EXHIBIT 2

REDACTED

EXHIBIT 3

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

POLAROID CORPORATION Plaintiff, v. HEWLETT-PACKARD COMPANY Defendant.	CIVIL ACTION NO. 06-738 (SLR)

**DECLARATION OF DR. PEGGY AGOURIS
REGARDING OKADA REFERENCE**

I, Dr. Peggy Agouris, declare as follows:

1. I am an expert in digital image processing. Polaroid Corporation retained me to render opinions relating to infringement and validity of U.S. Patent No. 4,829,381 ("the '381 patent"). I have personal knowledge of the matters stated in this declaration and would testify truthfully to them if called upon to do so.

2. On March 14, 2008, I submitted a report in this action titled, "Expert Report of Dr. Peggy Agouris Regarding U.S. Patent No. 4,829,381" ("Opening Report") (D.I. 151, Ex. B).

3. On April 18, 2008, I submitted a report in this action titled, "Rebuttal Expert Report of Dr. Peggy Agouris Regarding U.S. Patent No. 4,829,381" ("Rebuttal Report") (D.I. 151, Ex. C).

4. My expert qualifications, as disclosed in my Opening Report and Rebuttal Report, have not changed.

5. In my Opening Report, I explained how the algorithm disclosed in Polaroid's '381 patent operates. Without restating everything included in my Opening Report, which I

understand has already been submitted to the Court, it bears repeating that Polaroid's '381 patent: (1) transforms an image on a pixel-by-pixel basis; (2) calculates a local, not global, average for use in transforming the image; and (3) calculates a gamma for each pixel in the image being transformed as a function of the local average and input pixel intensity value — meaning the value of gamma will differ for differing local averages. In sum, when the '381 patent is transforming an image, the gamma value in Polaroid's '381 patent will not be constant for a given range of values. Indeed, the associated gamma value could change for every single pixel in the image.

6. In preparing my Rebuttal Report, I reviewed the Okada patent (U.S. 4,489,349) in great detail. In my Rebuttal Report I rendered the opinion regarding Okada that: "A function that transforms an input signal where the function is selected as a ratio of the average over a value within the dynamic range was already before the examiner because the Okada reference taught and disclosed that too. *See, e.g.*, Okada, Fig. 2; col. 4, lines 46-53 (POL 410-424)."

7. I understand that HP has asserted that my opinion quoted in paragraph 6 above means that the ratio, A_v/M, is contained in the gamma portion of the Okada reference. This is incorrect. Earlier, in my Rebuttal Report, I rendered the opinion that the Okada reference did not disclose the requirement that gamma be a function of a ratio, as well as other elements of the asserted claims. *See* D.I. 151, Ex. C at p. 10.

8. Rather, as explained more fully below, I was referring to the value "X", not gamma, disclosed in Okada when I rendered this opinion.

9. Okada discloses that the input-output characteristic is an adjustable gamma (γ) circuit where the output signal S_O is determined according to the following function: $S_O = X^\gamma$, where $0 \leq X \leq 1$. Ex. A, U.S. Pat. No. 4,489,349 to Okada, col. 2, lines 49–57 ("Okada").

10. Okada discloses that S_O is a signal representing the entire scene, not just a single pixel of the scene. *Id.*, col. 4, lines 9–10, col. 5, lines 3–4.

11. Okada discloses that X is derived from the average picture level ("APL") detecting circuit **20** in conjunction with the input signal S_I. *Id.*, Fig. 3.

12. Okada discloses that S_I is also a signal representing the entire scene, not just a single pixel of the scene. *Id.*, col. 3, line 48–col. 5, line 4.

13. Okada does not teach a specific algorithm for calculating gamma, only that gamma will be $^1/_2$ when the detected APL value is below 50%, unity when the detected APL value is at 50%, and 2 when the detected APL value is above 50%. *Id.*, col. 5, lines 21–32.

14. With regard to the APL detecting circuit **20**, Okada discloses that the APL detecting circuit **20** determines a global average brightness for the entire scene. *See id.*, col. 4, lines 34–38. The signal for the APL detecting circuit **20** is taught to be a percentage of the brightness in a scene. *Id.*, col. 5, lines 21–28. When a scene contains a large amount of information that is dark, the percentage will be low, which corresponds to an APL value near 0. *Id.*, col. 4, lines 34–40. By contrast, when a scene contains a large amount of information that is brightly lit, the APL percentage will be high, which corresponds to a value of 255 (for an 8-bit image). *Id.*, col. 4, lines 41–43.

15. With regard to X, Okada discloses that X is derived from the APL, which determines a global average. *Id.*, col. 2, lines 29–57, Fig. 3. Okada further discloses that X is normalized so that its value falls between 0 and 1. *Id.*, col. 2, lines 49–57. In order for X to fall between 0 and 1, it must be the ratio of a value that is a function of the global average to the maximum value of the dynamic range for the image, which is 255 for an 8-bit image. *See id.*, col. 2, lines 29–57, Fig. 3. Consequently, for an 8-bit image, X will be 0 when the global average value is 0. Similarly, when the global average value is 255, X will be 1. As the global

average varies from 0 to 255, X will vary from 0 to 1. It is this ratio that my opinion in paragraph 6 above pertained to.

16. With regard to γ, Okada discloses that only one gamma is used to transform the entire scene. *Id.*, col. 4, line 62–col. 5, line 4. Thus, unlike the '381 patent, which transforms an image on a pixel-by-pixel basis, Okada discloses a system that transforms a video image by operating on the entire scene, S_I. *Id.*, col. 2, lines 29–33.

17. In sum, Okada discloses a global correction method that transforms a video image by analyzing the entire image as a whole. As such, Okada only calculates a global, not local, average for the entire scene. And, Okada calculates one gamma value for use in enhancing every pixel in the entire image.

18. It is my opinion that Okada does not render the asserted claims of the '381 patent obvious. Specifically, given the nature of the Okada patent and what it discloses, one of ordinary skill in the art would not have been motivated to modify the system described in Okada by substituting A_v/M for gamma in Okada in an effort to obtain the algorithm contained in the '381 patent. Okada does not disclose any algorithm for selecting gamma so that it can transform a televised scene pixel-by-pixel. Indeed, Okada does not even suggest that the average brightness of a pixel — or even a group of pixels in the scene — can be measured. In addition, Okada does not suggest that gamma could be calculated using the signal from the APL detecting circuit **20** and then dividing it by a value that lies within the dynamic range of the video image. Indeed, Okada does not mention the dynamic range of the video image, or how the dynamic range could be used to impact the transformation process.

19. It is also my opinion that one of ordinary skill in the art would not have had a reasonable expectation of success by substituting A_v/M for gamma in Okada. The ratio claimed in the '381 patent works because A_v is a local average. There is nothing to suggest that substituting the global average calculated in Okada would yield the same results. In addition, the

algorithm claimed in the '381 patent consists of many more components than A_V/M. The additional components are integral in making the system claimed in the '381 patent effective. Okada does not disclose or even suggest the use of any of the other components claimed in the '381 patent's algorithm and one of skill in the art would not have had a reasonable expectation of success in transforming an image with a system that omits these components.

20. I declare under penalty of perjury that the foregoing is true and correct.

	6/5/08
Dr. Peggy Agouris	Date

TAB A

United States Patent [19]
Okada

[11] Patent Number: 4,489,349
[45] Date of Patent: Dec. 18, 1984

[54] **VIDEO BRIGHTNESS CONTROL CIRCUIT**

[75] Inventor: **Takashi Okada**, Yokohama, Japan

[73] Assignee: **Sony Corporation**, Tokyo, Japan

[21] Appl. No.: **230,394**

[22] Filed: **Feb. 2, 1981**

[30] **Foreign Application Priority Data**

Jan. 31, 1980 [JP] Japan 55-10667

[51] **Int. Cl.**[3] **H04N 5/68**
[52] **U.S. Cl.** **358/168**; 358/32; 358/164
[58] **Field of Search** 358/168, 39, 74, 243, 358/32, 164

[56] **References Cited**

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FOREIGN PATENT DOCUMENTS

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71604	1/1980	Japan	358/168

Primary Examiner—Tommy P. Chin
Attorney, Agent, or Firm—Lewis H. Eslinger; Alvin Sinderbrand

[57] **ABSTRACT**

A control circuit for controlling the relative brightness of a video signal includes an average picture level (APL) detector to measure the average brightness of the video signal and a brightness control circuit responsive to the detected average brightness to provide an output video signal wherein the picture areas containing most of the picture information are corrected to give greater contrast. In the output signal, portions corresponding to the black and peak white levels of the incoming video signals are provided substantially at the black and peak white levels, respectively, while the average brightness level of the output video signal is provided at an optimum level, such as 50%. The brightness control circuit can include a variable gamma correction circuit in which the value of gamma is automatically determined by a control signal provided from the APL detector.

21 Claims, 13 Drawing Figures

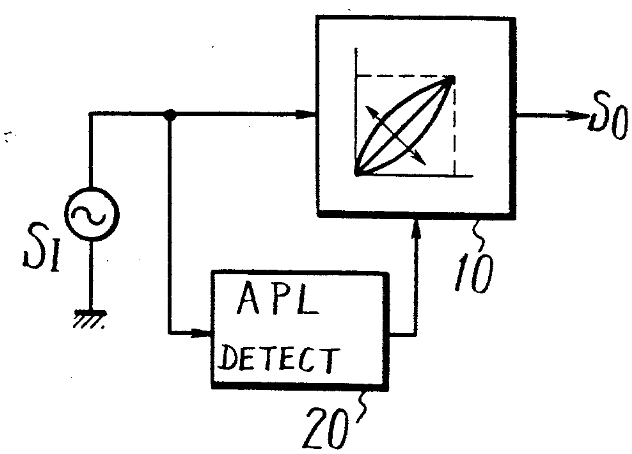


FIG. 1

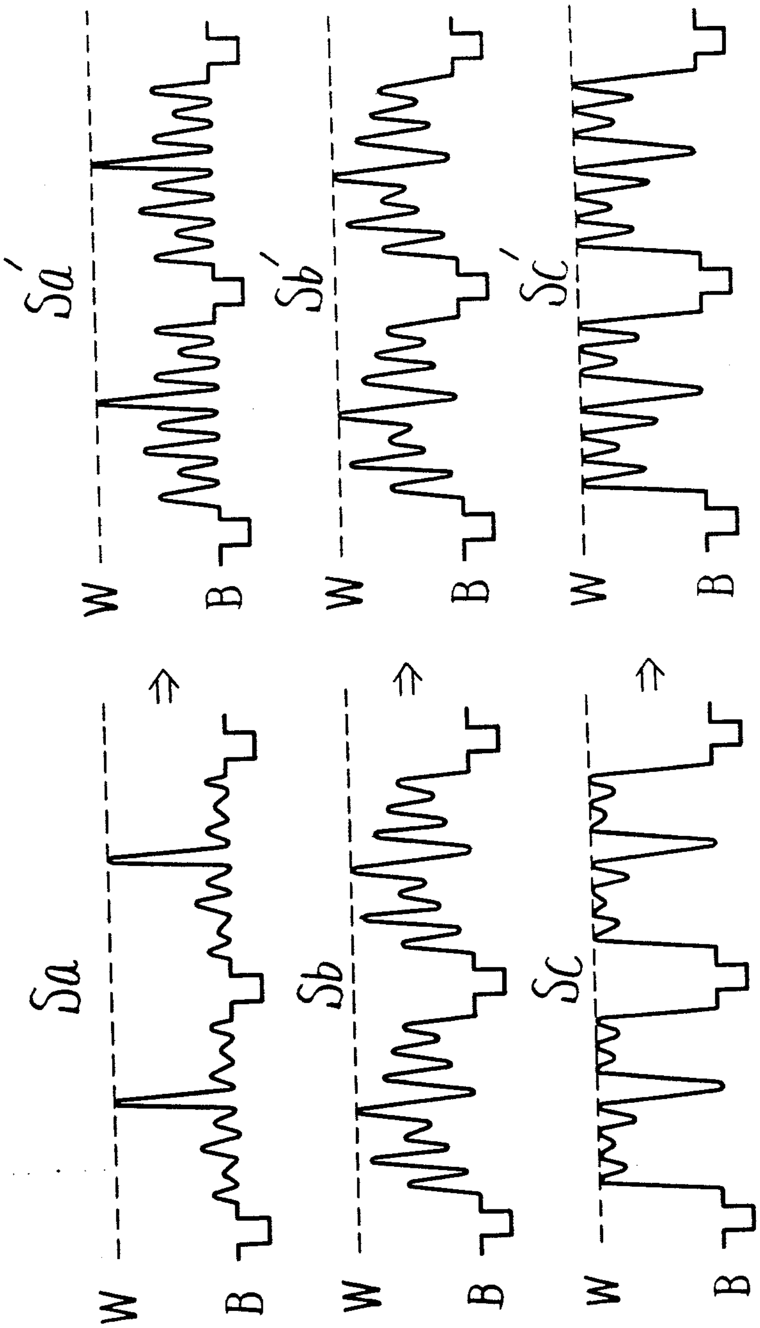


FIG. 2

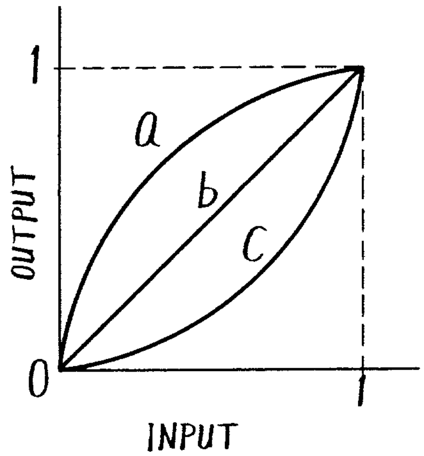


FIG. 3

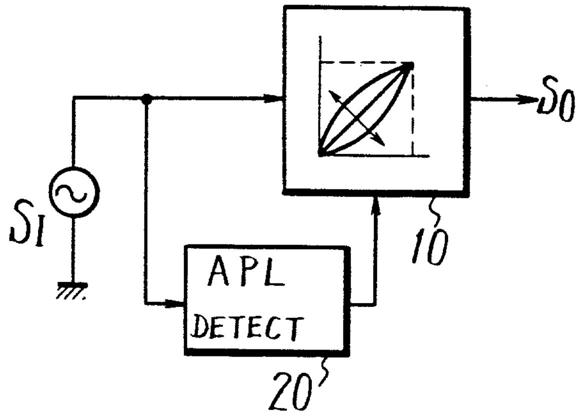


FIG. 4

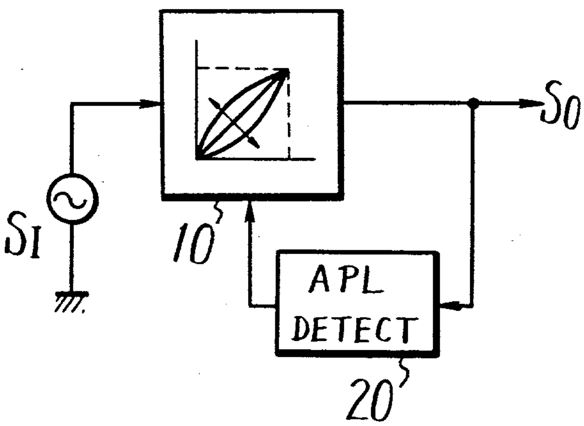


FIG. 5

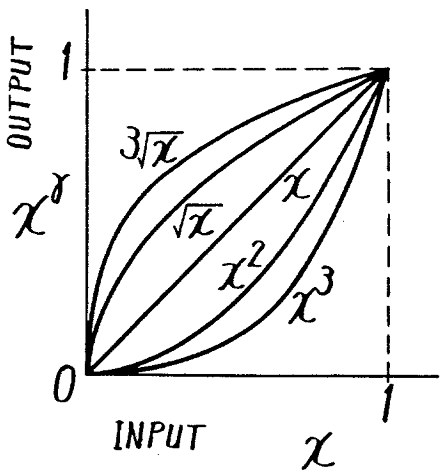


FIG. 6

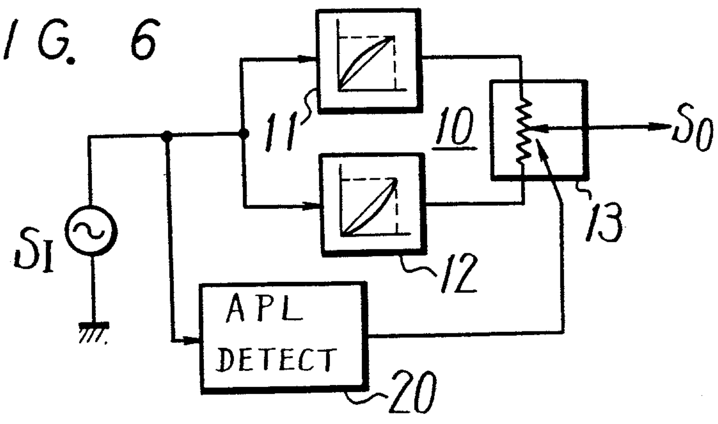

11
10
S_0
13
S_I
12
APL DETECT
20

FIG. 7

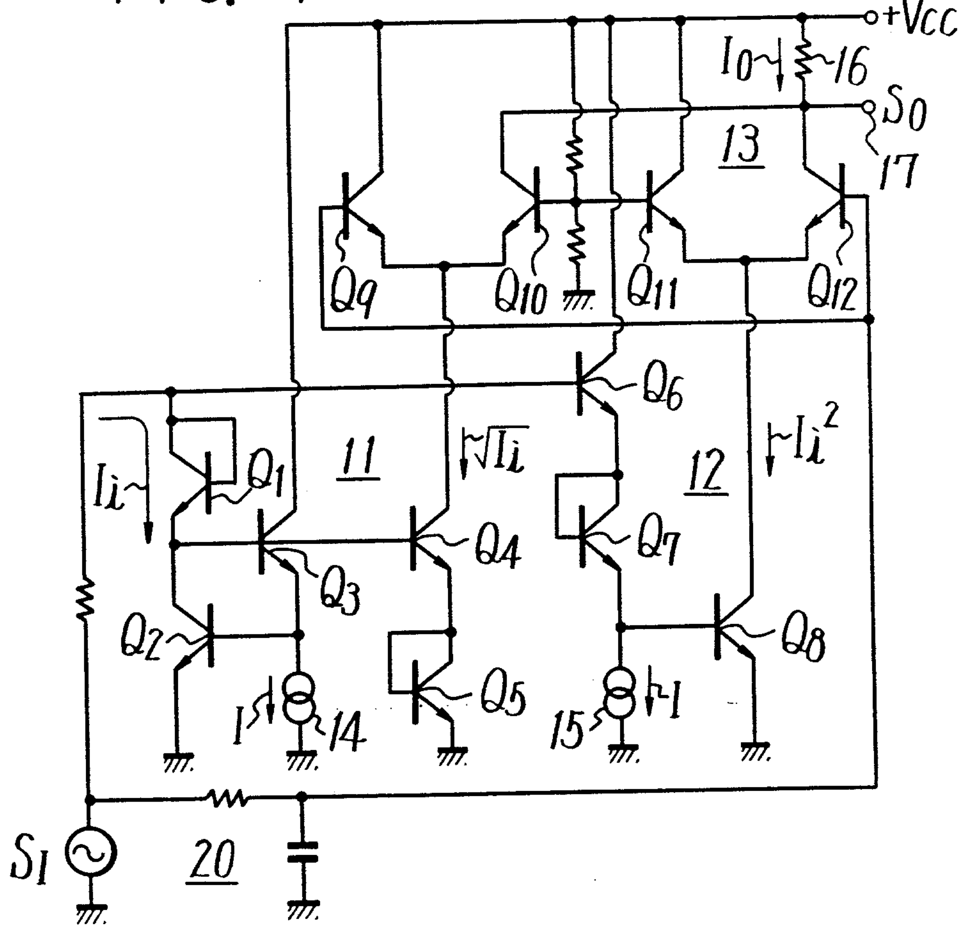
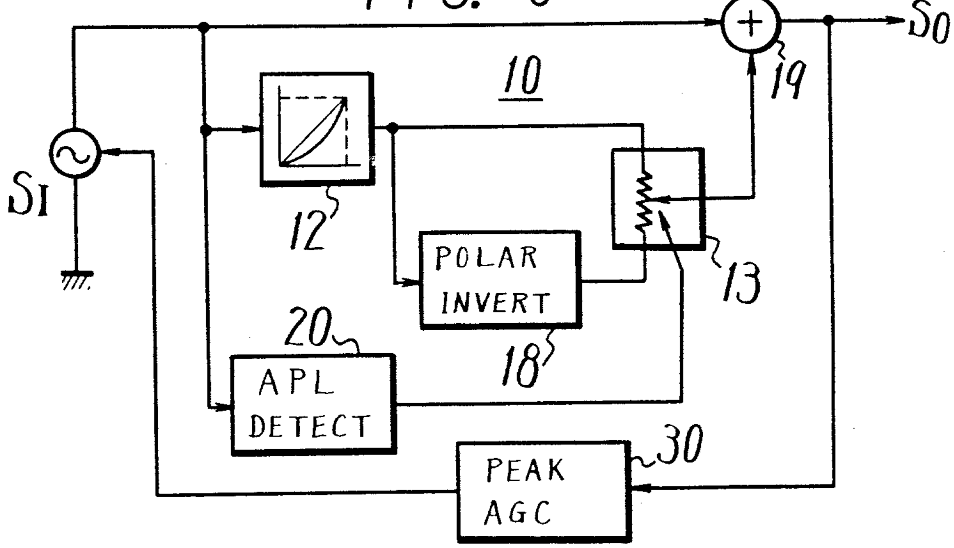
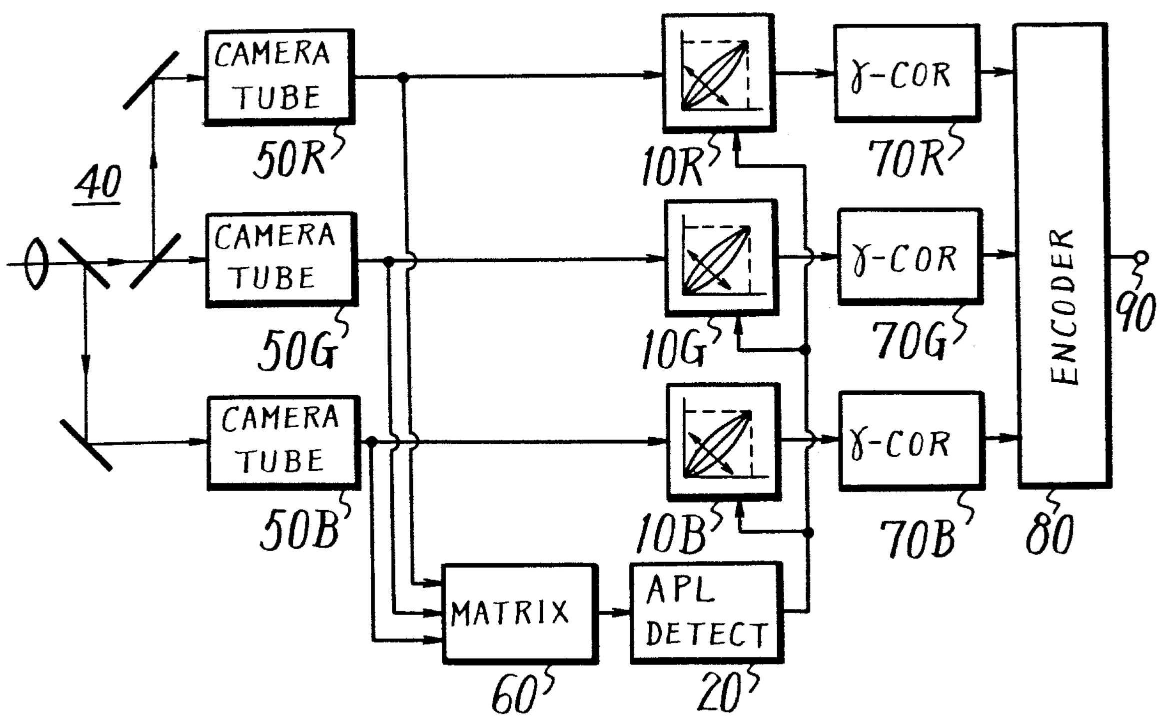

+Vcc
I_0
16
S_0
13
17
Q9
Q10
Q11
Q12
Q6
I_i
Q1
11
$\sqrt{I_i}$
12
I_i^2
Q4
Q7
Q3
Q2
Q8
Q5
I
14
15
I
S_I
20

FIG. 8



S0
19
10
SI
12
POLAR
INVERT
13
20
18
APL
DETECT
30
PEAK
AGC

FIG. 9



CAMERA
TUBE
50R
40
10R
γ-COR
70R
CAMERA
TUBE
50G
10G
γ-COR
70G
ENCODER
90
CAMERA
TUBE
50B
10B
γ-COR
70B
80
MATRIX
60
APL
DETECT
20

FIG. 10

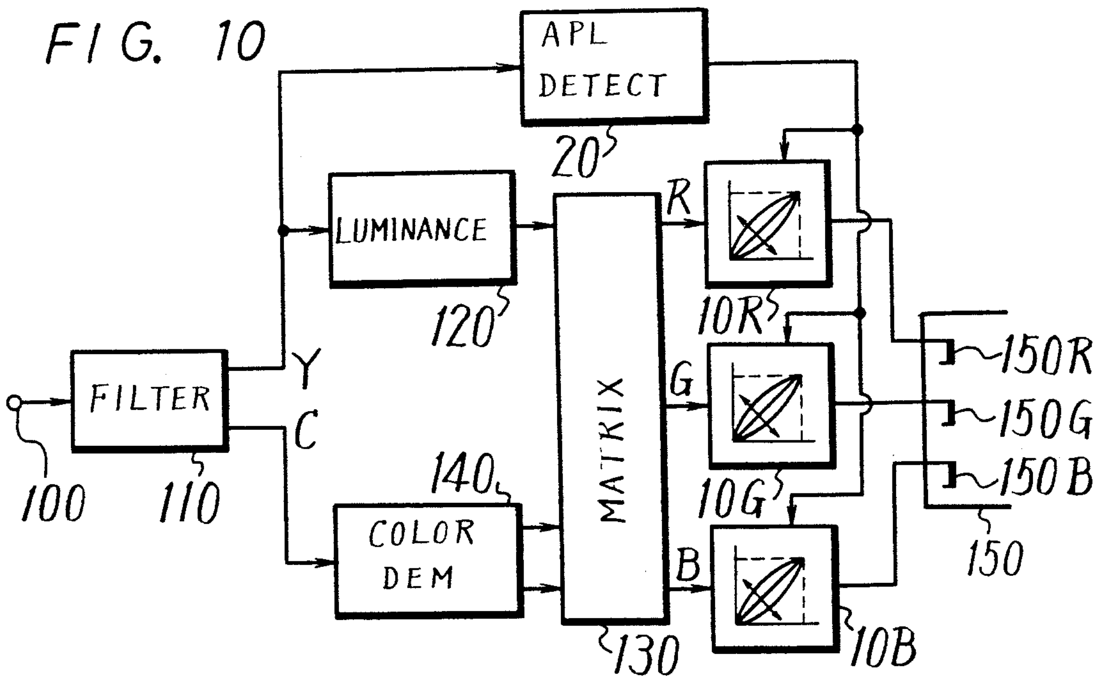


FIG. 11

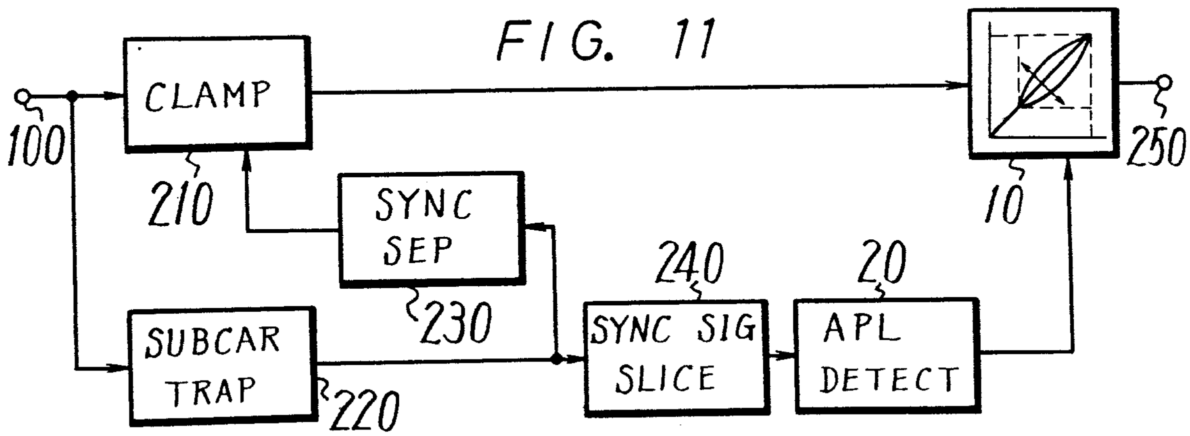


FIG. 12

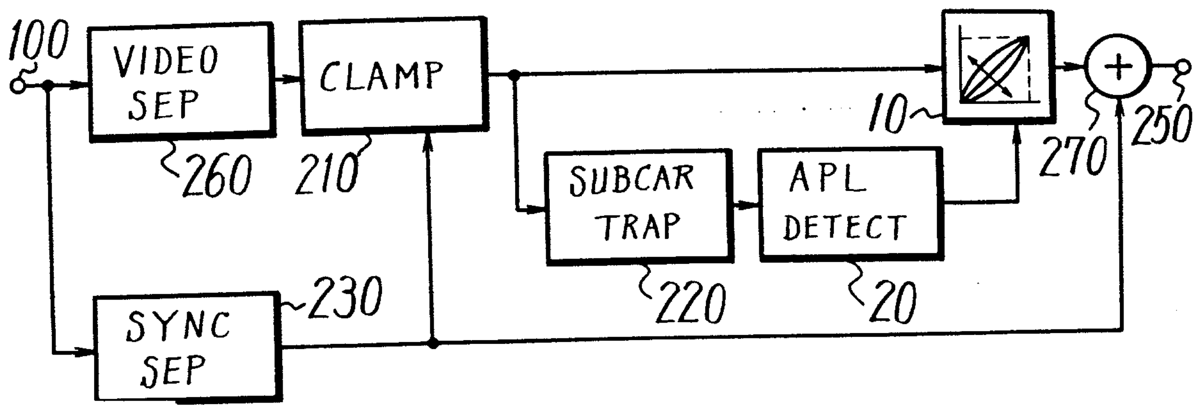
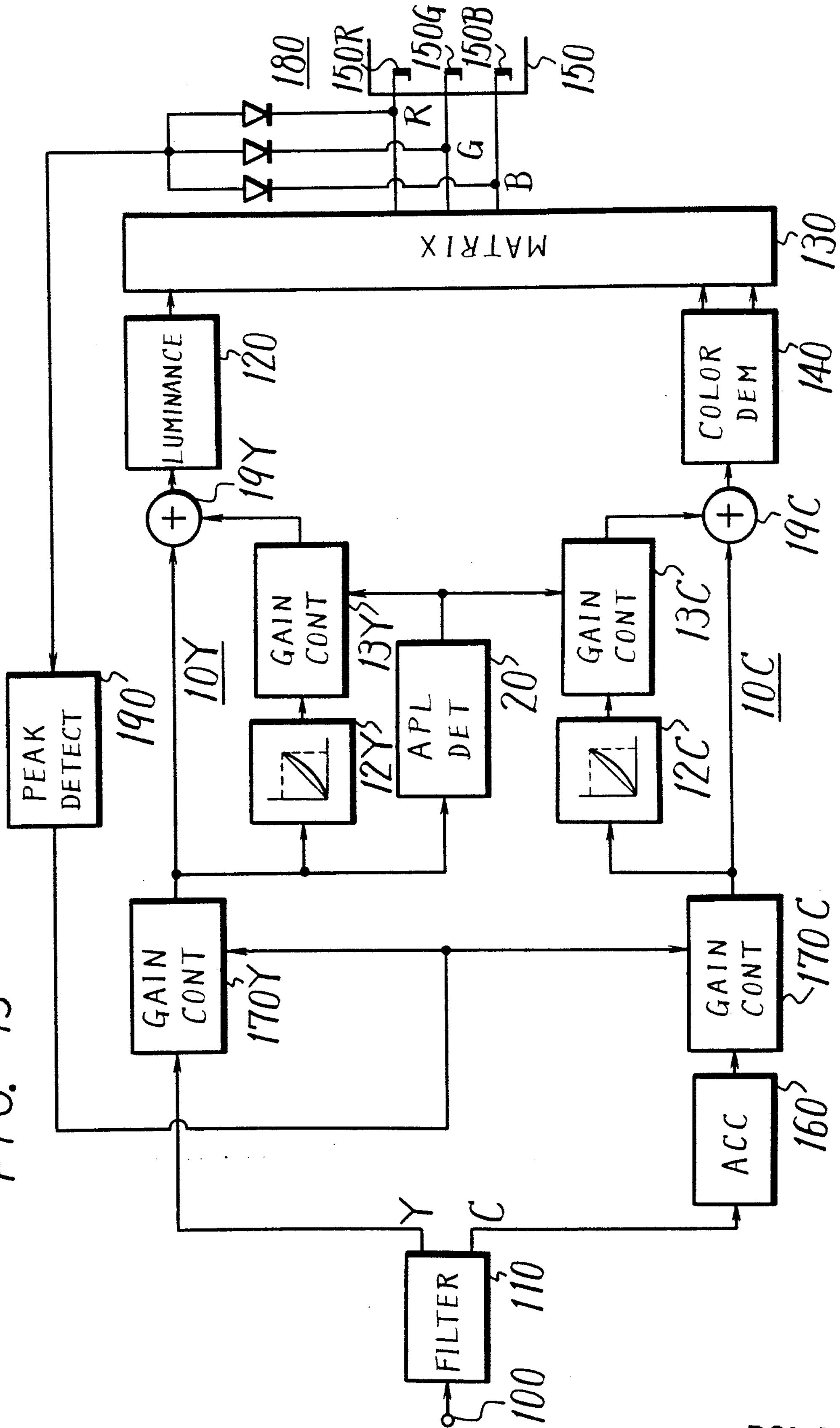


FIG. 13



180
150R
150G
150B
150
R
G
B
MATRIX
130
LUMINANCE
120
COLOR DEM
140
19Y
19C
GAIN CONT
13Y
GAIN CONT
13C
APL DET
20
12Y
12C
10Y
10C
PEAK DETECT
190
GAIN CONT
170Y
GAIN CONT
170C
ACC
160
Y
C
FILTER
110
100

VIDEO BRIGHTNESS CONTROL CIRCUIT

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to video signal processing circuitry and particularly relates to circuitry for controlling the brightness of a video signal so that detail of interest in a video picture will appear natural and have good contrast.

2. Brief Description of the Prior Art:

Natural illumination can have an extremely wide brightness range, and will necessarily have a vast range of contrast scales. The human eye adapts itself remarkably well for viewing naturally-lit objects and can with ease perceive detail in shadows and in brightly lit areas as well. Nevertheless, color video cameras and color video display apparatus are not easily adaptable to conditions of natural illumination, and current videocasting practices require special techniques, such as supplemental fill-in lighting, to provide a pleasing yet natural picture.

However, when such special techniques are unavailable, such as during on-scene news reporting, the picture presented on a display apparatus can be harsh and unpleasant. For example, if an on-the-spot newscast takes place at night with a newscaster at the news scene standing in front of a bright source, such as a flashing neon sign, the picture is likely to be harsh and without good detail. In such a scene, the presentation of the neon light is bright but the other objects in the picture are dark, and the contrast range among such objects is extremely narrow. Thus, except for the neon sign, the picture appears objectionably dim and observation of detail in the picture is difficult.

This problem can be understood by considering that while a color camera can be responsive to input light having an illumination range of from several hundred to several hundred thousand lux, the electrical output of the camera is limited to a range of, for example, 1 volt peak-to-peak. The input light must have a limited illumination range, e.g. 100 to 200 lux or several thousand to several tens of thousands of lux, in order that all of the video output signal remain within the range of 1 volt peak-to-peak. If these illumination limits are not observed, a conventional color television camera and display apparatus will not provide a good, pleasing picture.

Brightness adjustment in the video transmission is now carried out to a limited extent by use of so-called gamma (γ) correction. This process compensates for the differences in gamma values between the image pickup tube of a television camera and the cathode ray tube (CRT) of a television receiver.

Normally, the picked-up image is gamma-corrected before transmission so that the net gamma value of the image pickup and image display will be unity.

Conventionally, gamma correction is carried out on the image pickup side so that the output signal is skewed logarithmically at the saturated (white) side of the brightness range. Then, the skewed curve is expanded somewhat at the CRT, due to its inherent gamma characteristic, so that the picture brightness is correct.

Generally, if the overall gamma characteristic is logarithmic, the dark picture portions will have expanded contrast, and fine dark or shadow detail is reproduced. Conversely, if the gamma characteristic is exponential,

the bright portions will have expanded contrast, and detail in brightly lit areas will be clear.

Further, the lower illumination intensity portions of the video signal are affected by noise in the video apparatus. Consequently, a good video picture cannot be obtained for any scene unless the picture brightness is properly adjusted to span the entire dynamic range of the video apparatus. Accordingly, the actual brightness of an object in the scene does not convert exactly to a particular level of the video output signal, especially if the object is not evenly illuminated. The image of such an object in an unevenly-lit scene is not easily visible when reproduced on a video screen, and hence fatigues the eyes, making viewing somewhat tiring and unpleasant.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a technique wherein an image on a video screen is provided with the portion of the picture of most interest having relatively high contrast.

It is a further object of this invention to provide a correction circuit for use, for example, in a color television receiver, which will automatically adjust the brightness of the television signal so that a pleasing picture is presented on the display screen of the receiver, even when the scene is unevenly illuminated.

According to an aspect of this invention, a control circuit for controlling the brightness of a video signal that fluctuates between a peak dark level, such as the black level, and a peak bright level, such as the peak white level, about an average brightness level comprises an average picture level (APL) detector for detecting the average brightness level and, in response, providing a corresponding control signal, and a brightness adjusting circuit for optimizing the brightness of the video signal in response to the control signal, and providing a video output signal in which respective portions of the video output signal corresponding to portions of the incoming video signal at the peak dark level and the peak bright level are provided at the peak dark level and the peak bright level, but in which the average picture level is provided at an optimum level, such as the 50% brightness level.

The brightness adjusting circuit can favorably be formed as an adjustable gamma circuit, in which the value of gamma is determined in accordance with the control signal from the APL detector. In other words, the brightness adjusting circuit has an input-output characteristic such that for a video input signal having a level proportional to a value X, where X is in the range $0 \leqq X \leqq 1$, the video output signal is provided at a level proportional to a value X^γ, and the value γ is automatically determined in response to the control signal so that the video output signal has an APL at the optimum level.

A correction circuit according to this invention can be incorporated into a color television camera, in which case three brightness adjusting circuits can be included to be operative on respective primary color signals. The circuit of this invention can also be incorporated in a color television receiver. In such case, three brightness adjusting circuits can be provided, each operative upon a separate primary color signal, a single brightness adjusting circuit, operative upon both the chrominance and luminance components of a composite color video signal can be provided, or, alternatively, two brightness

adjusting circuits can be provided, one operative upon the luminance component, the other operative upon the chrominance component of a composite color video signal.

Various other features and advantages of the present invention will be apparent from the following description of several preferred embodiments, when considered with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a set of charts showing video waveforms before and after treatment in the correction circuit of this invention.

FIG. 2 is an input-output graph for explaining the operation of a portion of the correction circuit of this invention.

FIGS. 3 and 4 are diagrammatic views showing the basic construction of the circuit of this invention.

FIG. 5 is an input-output graph for explaining the present invention.

FIG. 6 is a systematic block diagram showing one embodiment of the correction circuit of this invention.

FIG. 7 is a detailed circuit diagram showing a practical example of the embodiment of FIG. 6.

FIG. 8 is a systematic block diagram showing another embodiment of the circuit of this invention.

FIG. 9 is a systematic block diagram of a three-tube color television camera incorporating the present invention therein.

FIG. 10 is a systematic block diagram of a portion of a video display apparatus incorporating the present invention.

FIGS. 11 and 12 are systematic block diagrams of video signal processing circuits for use in video receivers and incorporating the present invention.

FIG. 13 is a systematic block diagram of a portion of a video receiver incorporating the present invention.

DETAILED DESCRIPTIONN OF SEVERAL PREFERRED EMBODIMENTS

With reference to the drawings, and initially to FIG. 1, typical video signals Sa, Sb, Sc will be considered. In the charts of FIG. 1, the video signals have an amplitude ranging between a black level B and a peak white level W. Each of the video signals Sa, Sb, Sc, has a broad brightness amplitude range extending from black to white.

The signal Sa represents a dimly-lit scene having a single bright portion. In this case, most of the picture detail is in dark tones in the dimly lit portion, and only a small portion of the picture is bright. As a result, the signal-to-noise ratio of the picture is quite low and the signal Sa produces a dirty or hazy picture.

In the signal Sb, bright and dark tones are substantially uniformly distributed, indicating that the televised scene is ideally illuminated. The entire dynamic range of the signal Sb is used effectively so that the signal Sb has a high signal-to-noise ratio, and will produce a fine quality picture.

The signal Sc represents a scene which is brightly lit, but which includes a dark object. Here most of the detail is in bright tones, and the brightness of the picture will cause such detail to become very faint. Signals such as the signal Sc occur rather often when televising scenes out of doors, especially scenes including snow or scenes at a beach.

As aforesaid, the video signals Sa and Sc, although faithfully corresponding to the objects in the respective

televised scenes, include detail in the dimly and brightly lit portions, respectively, which will not be easy to see, due to the limited signal-to-noise ratio of the video display apparatus. According to this invention, the video signals Sa and Sc have their brightness levels optimized so that important detail in the picture portions having the largest amount of picture information can be observed with good contrast. Consequently, the image displayed on the video screen will be pleasing and easy to view.

In order to achieve this, the video signal is processed through a circuit having an input-output characteristic as shown in FIG. 2.

When the signal Sa is supplied an input, the input-output characteristic is caused to follow curve a of FIG. 2 so that the dimly-lit portions are expanded in contrast while the brightly-lit portions are compressed in contrast, with the result that the processed video signal Sa' is provided as an output video signal.

When the signal Sc is applied as an input, the input-output characteristic thereof follows curve c, so that the brightly-lit portions of the video picture are expanded, while the dimly-lit portions are compressed, so that an output signal Sc' is provided as shown in FIG. 1.

Finally, when the signal Sb is applied as an input, the input-output characteristic becomes a linear function as shown by curve b in FIG. 2, so that the output signal Sb' is provided, and the latter is identical with the input signal Sb.

In order to optimize the output video signals Sa' Sb', and Sc', the input-output characteristic must be changed continuously and automatically according to the information distribution of the input signals Sa, Sb, and Sc. Because the picture information distribution is akin to the proportional amount of bright and dimly-lit portions of the picture, the information distribution can be easily obtained by detecting the average picture level (APL) of the input signals Sa, Sb, and Sc. In other words, when the amount of informationn near the black level B is great, as in the signal Sa, the APL will be low. By contrast, when the amount of information near the peak white level W is great, as in the signal Sc, the APL will be high. Because the Sb has information distributed uniformly between the back B and peak white level W, the signal Sb will have an APL of about 50%.

Accordingly, the input-output characteristic a of FIG. 2 is selected for low APL values, the characteristic c is selected for high APL values, and the linear characteristic b is selected when the APL is at or near its optimum level of 50%. Further, when the APL is at some intermediate level, the input-output characteristic can be selected intermediate the curves a and b or intermediate the curves b and c.

Throughout the following description of various embodiments of this invention, common elements will be identified with the same reference characters, and a description of such elements will be provided only with respect to the embodiment with which they are first introduced.

One embodiment showing the basic construction of a correction circuit according to this invention is illustrated in FIG. 3. A video input information signal Si is furnished to an input of a variable correction circuit 10 and is also furnished to an APL detecting circuit 20. The latter detects the APL of the input signal Si and provides a control signal to a control input of the variable correction circuit 10. The variable correction circuit 10 automatically adjusts its input-output character-

istic in response to the control signal, and thus also, the input-output characteristic varies as a function of the detected APL. Consequently, the variable correction circuit provides an optimized output signal S_O.

Another example of the control circuit of this invention is shown in FIG. **4**, wherein the output signal S_O is fed back to the APL detecting circuit **20**, so that the input-output characteristic of the variable correction circuit **10** is determined in accordance with the average picture level of the output signal S_O.

The open-loop configuration of FIG. **3** has the advantage of fast and reliable response to changes in APL, while the closed-loop configuration of FIG. **4** has the advantage of superior accuracy in correcting the brightness characteristic of the video signal.

Practical input-output characteristics of the variable correction circuit are illustrated in FIG. **5**, in which the absissa represents an input while the ordinate represents an output X^γ. Here, the input and output remain between values of "0" (representing the black level) and "1" (representing the peak white level). The value of γ is changed according to the detected APL value. For example, when the APL is detected to be below 50%, γ is selected as $\delta=\frac{1}{2}$, and the output becomes $\sqrt{X}$; when the detected APL is at 50%, γ is selected as unity, and the output becomes X; and when the detected APL is above 50%, γ is selected as $\gamma=2$, and the outout becomes X^2. For extreme values of the detected APL, γ can be selected as $\gamma\pm\frac{1}{3}$ so that the output becomes $\sqrt[3]{X}$ when the detected APL is extremely low, and $\gamma=3$ so that the output becomes X^3 when the detected APL is extremely high.

A practical embodiment of the correction circuit of this invention is shown in FIG. **6**, and the details thereof are illustrated in FIG. **7**. In this embodiment, the variable correction circuit **10** is composed of a first correction circuit **11** having an input-output characteristic of $\gamma=\frac{1}{2}$ (i.e., a square-root circuit with an output $\sqrt{X}$), and a second correction circuit **12** having an input-output characteristic of $\gamma=2$ (i.e., a squaring circuit with an output X^2). When the input video signal S_I is applied to respective inputs of each of the first and second correction circuits **11** and **12**, the latter in turn provide first and second corrected video signals which are proportional to $\sqrt{X}$ and X^2, respectively. A summing circuit **13** combines the first and second corrected video signals in proportional amounts depending on the value of the control signal from the APL detector **20**. Thus, when the APL is low, only the first corrected video signal $\sqrt{X}$ is provided. When the APL is high, only the second corrected video signal $\sqrt{X}$ is provided. When the APL is determined to be 50%, the first and second corrected video signals are provided in equal amounts so that the output signal S_O has the output characteristic

$$\frac{\sqrt{X}+X^2}{2},$$

that is, the output signal S_O will be approximately the same as the input signal S_I. It should be noted that for $0<X<1$, the value of the expression

$$\frac{\sqrt{X}+X^2}{2}$$

will be very close to the value $X(\gamma=1)$, and the two expressions will have the same value at 0, 1, and approximately 0.38.

In the practical circuit shown in FIG. **7**, the first correction circuit **11** includes a constant current source **14**; a diode-connected transistor Q_1, having its base and collector connected together to receive an input signal current I_I; an auxiliary transistor Q_2 having its collector coupled to the emitter of the transistor Q_1 and its emitter connected to ground; an input transistor Q_3 having its collector connected to a voltage source V_{CC}, its base connected to the emitter of the transistor Q_1, and its emitter coupled to the constant current source **14** and also to the base of the transistor Q_2; and an output transistor Q_4 having its base connected to the base of transistor Q_3 and the emitter of the transistor Q_1, and its collector providing the first output correction signal current $\sqrt{I_i}$. A diode-connected transistor Q_5 is connected between the emitter of the transistor Q_4 and ground.

The second correcting circuit **12** includes a constant current source **15**, and input transistor Q_6 having its base connected to receive the input signal S_I and its collector connected to the voltage source V_{CC}; a diode-connected transistor Q_7 having its base and collector connected to the emitter of the transistor Q_6 and its emitter connected to the constant current source **15**; and an output transistor Q_8 having its base connected to the emitter of the transistor Q_7, its emitter connected to ground, and its collector providing a second output correction signal current I_i^2.

The summing circuit **13** is formed of a load resistor **16** connected to the voltage source V_{CC}; a first transistor Q_9 having its collector connected to the voltage V_{CC} and its base connected to receive the control signal from the APL detecting circuit **20**; a second transistor Q_{10} having its collector connected to the load resistor **16** and its emitter, together with the emitter of the first transistor Q_9 connected to the collector of the output transistor Q_4. The summing circuit **13** also includes a third transistor Q_{11} having its collector connected to the voltage source V_{CC}, and its base together with the base of the transistor Q_{10} biased at a predetermined level. Also included is a fourth transistor Q_{12} having its collector connected to the load resistor **16**, its base connected to receive the control signal from the APL detecting circuit **20**, and its emitter, together with the emitter of the third transistor Q_{11} connected to the collector of the output transistor Q_8. An output terminal **17** is connected to the junction of the load resistor **16** with the collectors of the transistors Q_{10} and Q_{12}.

In this embodiment, the APL detecting circuit **20** is a low-pass filter composed of a resistor and a capacitor.

The specific operation of the embodiment depicted in FIG. **7** is explained as follows:

In this circuit, if equal constant currents I are provided from each of the constant current sources **14** and **15**, the base-emitter forward voltages of the transistors Q_1 to Q_8 are represented as V_{BE1} to V_{BE8}, respectively, and the transistors Q_1 to Q_8 have respective collector currents I_1 to I_8, respectively, the following relationship is obtained:

$$V_{BE2}+V_{BE3}=V_{BE4}+V_{BE5} \tag{1}$$

As is well known, the base-emitter forward voltage V_{BE} of a transistor can be expressed as a function of its collector current I_c and the saturation current I_s thereof according to the following equation:

$$V_{BE}=KT/g \ln Ic/I_s \quad (2)$$

where g is an electric charge constant relating to the number of charge carriers in the base-emitter junction, K is the Boltzmann constant, and T is a constant having units of temperature. Accordingly, the currents of the transistors Q_2 to Q_5 will have the relationship

$$I_2 \cdot I_3 = I_4 \cdot I_5 \quad (3)$$

In this circuit, I_2 is equal to the input current I_i, I_3 is equal to the current I of the constant current source **14**, and I_4 is equal to I_5, so that the latter currents can be expressed as $I_4=I_5=I_m$. Accordingly, the following relationship results:

$$I_i \cdot I = I_m^2 \quad (4)$$

that is,

$$I_m = \sqrt{I} \cdot \sqrt{I_i} \quad (5)$$

If it is assumed that the current I of the constant current source **14** is unity, then I=1, and

$$I_m = \sqrt{I_i} \quad (6)$$

Thus, the first correction circuit **11** has a gamma of ½.

At the same time, in the second correction circuit **13**, the base-emitter voltages of the transistors Q_6, Q_7, and Q_8 can be expressed

$$V_{BE1}+V_{BE3}+V_{BE2}=V_{BE6}+V_{BE7}+V_{BE8} \quad (7)$$

and the respective collector currents can be expressed as

$$I_1 \cdot I_3 \cdot I_2 = I_6 \cdot I_7 \cdot I_8 \quad (8)$$

In addition, because the currents I_1 and I_2 are each equal to the input current I_i, and the currents I_3, I_6, and I_7 are each identical with the current I from the constant current source **15**, if the current I_8 is expressed an I_n, the following relationship results:

$$I_i^2 \cdot I = I^2 \cdot I_n \quad (9)$$

or

$$I_n = (1/I) \cdot I_i^2 \quad (10)$$

thus, if, as aforesaid, the current I is unity, then

$$I_n = I_i^2 \quad (11)$$

Consequently, the second correction circuit **12** has a gamma of 2.

In the summing circuit **13**, a current $k \cdot \sqrt{I_i}$ flows through the collector of the second transistor Q_{10} while a current of $(1-k)I_i^2$ flows through the collector of the fourth transistor Q_{12}, where k is a positive number less than unity which is determined according to the average picture level voltage from the APL circuit **20**. As a result, an output current I_O flows through the load resistor **16**, and can be expressed as follows:

$$I_0 = k\sqrt{I_i} + (1-k)I_i^2 \quad (12)$$

In other words, when the APL is detected to be extremely low, the transistors Q_9 and Q_{12} are rendered nonconductive so that the constant k is unity, and the output current I_O equals the current $\sqrt{I_i}$ from transistor Q_4. When the APL is approximately 50%, k=½, and the output current I_O can be expressed.

$$I_0 = \frac{\sqrt{I_i} + I_i^2}{2}.$$

When the APL is determined to be high, the second and third transistors Q_{10} and Q_{11} are rendered nonconductive so that the constant k=0 and I_O can be expressed

$$I_0 = \sqrt{I_i}$$

Of course, for intermediate values of the detected APL, the constant k will take on intermediate values of gamma so that the output signal S_O will provide a video picture of optimum contrast.

Another embodiment of the correction circuit according to this invention is illustrated in FIG. **8**. In this embodiment, the variable correction circuit **10** is formed of the squaring circuit **12** having its input coupled to receive the input signal S_i, a polarity inverter **18** coupled to the output of the squaring circuit **12**, and the summing circuit **13** connected to combine the output of the squaring circuit **12** with an inverted replica thereof provided from the polarity inverter **18**. Also in this embodiment, an adder **19** is included to combine the input video signal with the resultant video signal provided from the summing circuit **13**.

The summing ratio of the corrected signal from the squaring circuit **12** and the inverted replica thereof is changed according to the control signal furnished from the APL detector **20**. Since the output of the polarity inverter **18** is expressed as $-X^2$, the output of the summing circuit **13** can be expressed as

$$mX^2-(1-m)X^2=(2m-1)X^2$$

so that the output signal from the adder **19** can be expressed as

$$X+(2m-1)X^2.$$

Hence, the input-output characteristic of the variable correction circuit **10** is changed according to the value of m in accordance with the detected average picture level. However, in order to maintain the brightness range of the output video signal S_O as a constant, a peak automatic gain control circuit **30** is coupled from the output of the adder **19** back to a point in advance of the variable correcting circuit **10**.

It should be noted that in this embodiment if the value of m is selected as ¼, the variable correction circuit **10** will have a gamma approximately ½, if the value of m is selected as ½, the gamma will be unity, and if the value of m is selected as 1, the gamma will be 2.

FIG. **9** illustrates a three-tube type color television camera incorporating a correction circuit according to the present invention. In this camera, an optical system

40 separates the image into red, green, and blue images which are incident on respective red, green, and blue image pickup tubes **50R**, **50G**, and **50B**. As a result, the latter provide respective red, green, and blue color signals. These color signals are provided to a matrix circuit **60** which then derives from them a luminance signal and supplies the same to the APL detector **20**. In this embodiment, respective variable correction circuits **10R**, **10G**, and **10B** are provided to control the brightness of the corresponding red, green, and blue color signals. The control signal from the APL detector **20** is provided to each of the vertical correction circuits **10R**, **10G**, and **10B** to control their respective input-output characteristics. Then, the corrected red, green, and blue color signals from the circuits **10R**, **10G**, and **10B** are supplied through respective γ-correction circuits **70R**, **70G**, and **70B** to an NTSC encoder **80**, and the latter provides an encoded composite color video signal at an output terminal **90** thereof.

If instead of a plural-tube camera, a single-tube type color camera is employed, in which the luminance signal is separated, the average picture level of the luminance signal can be detected without the necessity of employing the matrix circuit **60**.

A television receiver incorporating a correction circuit according to this invention is illustrated in FIG. **10**. In this receiver, a composite color video signal applied to an input terminal **100** thereof is separated in a filter circuit **110** into a luminance component Y and a chrominance component C. The luminance component Y is furnished through a luminance signal processing circuit **120** to a matrix circuit **130**, and is also furnished to the APL detector **20**. The chrominance component C is furnished to color demodulator **140** which then supplies a pair of color difference signals to the matrix circuit **130**. The latter then provides primary color signals R, G, and B to a color cathode ray tube **150**. In this receiver, respective variable correction circuits **10R**, **10G**, and **10B** are provided between the matrix circuit **130** and respective cathodes **150R**, **150G**, and **150B** of the color cathode ray tube **150**. Here, the separated red, green, and blue color signals are adjusted in brightness according to the average luminance level detected by the APL detector **20**.

Another embodiment of this invention is illustrated in FIG. **11**, in which the luminance component and the chrominance component are not separated, as they are in the embodiment of FIG. **10**. In this embodiment, the composite color video signal is applied from the input terminal **100** to a clamp circuit **210** and thence to the variable correction circuit **10**. The composite color video signal is also supplied to a subcarrier trap circuit **220**, which blocks the chrominance component modulated on the subcarrier, so that only the luminance signal and the synchronizing pulse are passed. The synchronizing pulse is separated out therefrom in a synch separator **230** and is furnished to the clamp circuit **210** so that the latter can clamp the video signal to the pedestal level of the synchronizing pulse. The luminance component is furnished from the subcarrier trap **220** through a synch signal slice circuit **240** to the APL detector **20**. A corrected composite color video signal is then applied from the variable correction circuit **10** to an output terminal **250**. In this embodiment, the variable correction circuit **10** has an input-output characteristic that varies as a function of the control signal from the APL detector **20** during the line scanning portion of the video signal, but has a linear input-output characteristic ($\gamma=1$) during the occurrence of the synchronizing pulse.

Another embodiment of the correction circuit of this invention is illustrated in FIG. **12**. It should be appreciated that the embodiment of FIG. **12** is a variation of the embodiment of FIG. **11**. In this embodiment, the luminance and chrominance components are not separated from one another, but the synchronizing pulse is separated out and is treated separately. Here, a video separator **260** is coupled to the input terminal **100** so that only the luminance and chrominance components are furnished to the clamp circuit **210**. The synch separator **230** is coupled in advance of the video separator **260**, and the separated synchronizing pulse is furnished therefrom to the clamp circuit **210** and also to an adder circuit **270** disposed after the variable correction circuit **10**. The composite color video signal, without the synchronizing pulse, is applied to the clamp circuit **210** where it is clamped to the pedestal level of the synchronizing pulse from the synch separator **230**, and the thus-clamped color video signal is supplied to the variable correction circuit **10**. The clamped color video signal is also supplied through the subcarrier trap circuit **220** to the APL detector **20** which detects the average picture level of the luminance component. The APL detector **20** then furnishes a control signal to the variable correction circuit **10** to control its input-output characteristic. Then, the corrected color video signal from the variable correcting circuit **10** is combined in the adder circuit **270** with the separated synchronizing pulse, so that a finally corrected composite color video signal is provided at the output terminal **250**.

Yet another video receiver incorporating the correction circuit according to this invention is illustrated in FIG. **13**. This video receiver combines the features of this invention with a circuit for dynamically controlling the amplitude of the video signal according to the picture contents, i.e., a so-called dynamic picture control circuit. Examples of such a dynamic picture control circuit are disclosed in U.S. Pat. No. 4,403,254, issued Sept. 6, 1983, and U.S. Pat. No. 4,298,885, issued Nov. 3, 1981, both of which have a common assignee herewith.

As illustrated in FIG. **13**, the separated luminance signal is furnished from the filter **110** to a luminance gain control circuit **170Y** and is then furnished to a luminance correction circuit **10Y**. The latter is formed in general like the embodiment of FIG. **8**, and includes a squaring circuit **12Y**, a gain control circuit **13Y**, and an adder circuit **19Y**. A corrected luminance signal is furnished from the adder circuit **19Y** through a luminance processing circuit **120** to the matrix circuit **130**. The luminance component Y is also furnished from the gain control circuit **170Y** to the APL dètector **20** which then detects the average luminance component. The chrominance component C is furnished through an automatic chroma control (ACC) circuit **160** to a chrominance gain control circuit **170C**, and thence to a chrominance correcting circuit **10C**. This circuit **10C** is basically similar to circuit **10Y** and to the embodiment of FIG. **8**, and includes a squaring circuit **12C**, a gain control circuit **13C**, and an adder circuit **19C**. The corrected chrominance signal is then furnished from the adder circuit **19C** to the color demodulator **140** which provides demodulated color difference signals to the matrix circuit **130**.

The matrix circuit **130** provides decoded primary color signals R, G, and B to the cathodes **150R**, **150G**,

and 150B and also to a minimum value detecting circuit 180, which here includes diodes having their cathodes connected to the cathodes 150R, 150G, and 150B of the cathode ray tube 150 and having their anodes connected to a peak detecting circuit 190. The output of the peak detecting circuit 190 then controls the gain of the gain control circuits 170Y and 170C.

In this embodiment, the control signal from the APL detector 20 is furnished to both the gain control circuit 13Y and the gain control circuit 13C of the respective luminance and chrominance variable correcting circuits 10Y and 10C.

In each of the above embodiments of this invention, the brightness of a video signal is automatically controlled according to the information carried within the video signal, thereby providing an optimum contrast ratio to that portion of the video picture having the greatest amount of information. As a result, according to this invention, it is possible to provide a reproduced picture which is natural and pleasing to the eye, and which has sufficient contrast so that the picture is neither harsh nor washed out.

Although certain preferred embodiments of this invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by persons skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

What is claimed is:

1. A control circuit for controlling the brightness of a video signal that fluctuates between a peak dark level and a peak bright level about an average brightness level comprising:

brightness controlling means having a signal input to which the video signal is applied as an input video signal and a signal output from which an output video signal is provided, said brightness controlling means being operable by a control signal for controlling the brightness of the video signal so that respective portions of said output video signal corresponding to portions of the input video signal at said peak dark level and at said peak bright level are provided substantially at said peak dark and bright levels while the average picture level of said output video signal is provided at a predetermined optimum level;

average picture level detecting means for detecting the average brightness level of at least one of said input and output video signals and providing said control signal in response to the detected average brightness level; and

a variable gamma correction circuit included in said brightness controlling means and having an input-output characteristic such that for the input video signal having a level proportional to a value X, where X is in the range $0 \leqq X \leqq 1$, said video signal is provided at a level proportional to a value X^γ; and the value of γ is automatically determined in response to the control signal from said average picture level detecting means.

2. A control circuit according to claim 1; wherein said average picture level detecting means is connected to receive said input video signal in advance of said brightness controlling means to provide said control signal as a function of the average brightness level of said input video signal.

3. A control circuit according to claim 1; wherein said average picture level detecting means is connected to receive said output video signal from said brightness controlling means to provide said control signal as a function of the average brightness level of said output video signal.

4. A correction circuit according to claim 1; wherein said variable gamma correction circuit includes means for selecting the value of γ to be a number whose magnitude is less than unity when said average brightness level is detected to be less than said predetermined optimum level, to be unity when said average picture level is detected to be substantially at said predetermined optimum level, and to be a number greater than unity when said average brightness level is detected to be greater than said predetermined optimum level.

5. A control circuit according to claim 4; wherein the value of γ is selected to be $\frac{1}{2}$ and 2, respectively when said average brightness level is detected to be less than and greater than said predetermined optimum level.

6. A control circuit for controlling the brightness of a video signal that fluctuates between a peak dark level and a peak bright level about an average brightness level comprising:

brightness controlling means having a signal input to which the video signal is applied as an input video signal having a level proportional to a value X, where X is in the range $0 \leqq X \leqq 1$, and a signal output from which an output video signal is provided, said brightness controlling means being operable by a control signal for controlling the brightness of the video signal so that respective portions of said output video signal corresponding to portions of the input video signal at said peak dark level and at said peak bright level are provided substantially at said peak dark and bright levels while the average picture level of said output video signal is provided at a predetermined optimum level; said brightness controlling means including first correction circuit means having an input-output characteristic such that a first corrected video signal is provided at a level proportional to $\sqrt{X}$, second correction circuit means having an input-output characteristic such that a second corrected video signal is provided at a level proportional to X^2 and summing circuit means for combining said first and second corrected video signals in relative amounts depending upon said control signal so that the combined first and second corrected video signals are provided as said output video signal; and

average picture level detecting means for detecting the average brightness level of said input video signal and providing said control signal in response to the detected average brightness level.

7. A control circuit according to claim 6; wherein said first correction circuit means includes a constant current source, an input transistor having an input electrode coupled to receive said input video signal and an output electrode coupled to said constant current source, an auxiliary transistor having a control electrode coupled with the output electrode of the input transistor and current carrying electrodes respectively coupled to the control electrode of the input transistor and to a reference point; and an output transistor having a control electrode coupled to the control electrode of said input transistor and an output electrode providing said first corrected video signal.

8. A control circuit according to claim 7; wherein said first correction circuit means further includes a diode coupled in advance of the control electrode of said input transistor; and wherein said second correction circuit means includes a constant current source, an input transistor having a control electrode coupled to receive said input video signal and an output electrode, a diode having one electrode coupled to the output electrode of the input transistor and another electrode coupled to said constant current source, and an output transistor having a control electrode coupled to said other electrode of said diode and an output electrode providing said second corrected video signal.

9. A control circuit according to claim 6; wherein said summing circuit means includes a load impedance; a voltage source; a first transistor having a control electrode coupled to receive said control signal, one current-carrying electrode coupled to said voltage source, and another current-carrying electrode coupled to receive said first corrected video signal; a second transistor having a control electrode, an input electrode coupled to said another current-carrying electrode of said first transistor, and an output electrode coupled to said load impedance; a third transistor having a control electrode, one current-carrying electrode coupled to said voltage source and another current-carrying electrode coupled to receive said second corrected video signal; means biasing the control electrodes of said second and third transistors to a predetermined level; a fourth transistor having a control electrode coupled to receive said control signal, an input electrode coupled to said other current carrying electrode of said third transistor, and an output electrode coupled to said load impedance; and output means coupled to said output impedance to provide said output video signal.

10. A control circuit for controlling the brightness of a video signal that fluctuates between a peak dark level and a peak bright level about an average brightness level comprising:

brightness controlling means having a signal input to which the video signal is applied as an input video signal and a signal output from which an output video signal is provided, said brightness controlling means being operable by a control signal for controlling the brightness of the video signal so that respective portions of said output video signal corresponding to portions of the input video signal at said peak dark level and at said peak bright level are provided substantially at said peak dark and bright levels while the average picture level of said output video signal is provided at a predetermined optimum level; said brightness controlling means including correction circuit means having an input terminal to which said input video signal is applied and an output terminal at which a corrected video signal is obtained, the latter being substantially proportional to the square of the input video signal, polarity inverter means coupled to the output terminal of the correction circuit means for providing an inverted version of said corrected video signal, summing circuit means for combining said corrected video signal and the inverted version thereof in relative amounts depending upon said control signal to provide a resultant video signal and adder means for combining the input video signal with said resultant video signal to produce said output video signal; and

average picture level detecting means for detecting the average brightness level of said input video signal and providing said control signal in response to the detected average brightness level.

11. A control circuit according to claim 10; further comprising peak automatic gain control circuit means for controlling the strength of the input video signal in response to at least one peak value of said output video signal.

12. A color television camera providing a composite color video signal comprising a plurality of pickup tubes each responsive to light of a respective primary color to produce a corresponding primary-color signal that fluctuates between a peak dark level and a peak bright level about an average brightness level; average picture level detecting means for detecting the average brightness level of the composite color video signal and providing a control signal in response to such detected average brightness level; a plurality of variable correction circuits each coupled to a respective pickup tube for processing a respective primary color signal, each such variable correction circuit being coupled to receive said control signal and having an input-output characteristic such that for the associated respective primary-color signal having a level proportional to a value X, where X is in range $0 \leqq X \leqq 1$, said variable correction circuit provides an output signal substantially proportional to a value X^γ, where the value γ is automatically determined in response to the control signal from the average picture level detecting means; and encoding means coupled to receive the output signals from said variable correction circuits for providing said composite color video signal as a brightness-corrected composite color video signal.

13. A color television camera according to claim 12; wherein said composite color video signal includes a luminance component; and said average picture level detecting means includes a matrix circuit having inputs coupled to said plurality of pickup tubes and an output providing said luminance component, and also includes average luminance level detecting means coupled to said matrix circuit and responsive to said luminance component for providing said control signal.

14. A control circuit for controlling the brightness of a video signal in a color television display apparatus having a color display tube providing a color video picture in response to a plurality of primary color signals, and in which a chrominance signal and a luminance signal that varies between a black level and a peak white level about an average brightness level are combined to form said plurality of primary color signals, comprising

average picture level detecting means coupled to receive the luminance signal for detecting the average brightness level of said luminance signal and providing a control signal in response to the detected average brightness level; and a plurality of variable correction circuits each operative upon a respective primary color signal and disposed in advance of said color display tube, each such variable correction circuit being coupled to receive said control signal and having an input-output characteristic such that for the associated respective primary-color signal having a level proportional to a value X, where X is in the range $0 \leqq X \leqq 1$, said variable correction circuit provides to the associated respective beam-generating device, an output signal that is substantially propor-

tional to a value X^{γ}, where the value of γ is automatically determined in response to said control signal.

15. A correction circuit for controlling the brightness of a composite color video signal having a luminance component that fluctuates between a black level and a peak white level about an average luminance level, a chrominance component, and a synchronizing pulse with a pedestal portion, comprising clamping means for establishing the black level of said video signal as a function of said pedestal portion; means for providing said synchronizing pulse to said clamping means; average picture level detecting means for providing a control signal in response to the average luminance level of said luminance component; and brightness controlling means coupled to receive said control signal and having a signal input to which at least said luminance and chrominance components are applied and a signal output from which an output composite video signal is obtained, for controlling the brightness of the composite video signal so that respective portions of said output composite video signal corresponding to portions of the luminance component at said black level and at said peak white level are provided substantially at said black and peak white levels, while said output composite video signal has an average picture level that is provided at a predetermined optimum level.

16. A correction circuit according to claim **15**; wherein said brightness controlling means has an input-output characteristic that varies as a function of said control signal between occurrences of said synchronizing pulse but has a constant input-output charcteristic during occurrence of said synchronizing pulse.

17. A correction circuit according to claim **16**; further comprising synch signal slicing means in advance of said average picture level detecting means for blocking said synchronizing pulse.

18. A correction circuit according to claim **15**; further comprising separating means in advance of said clamping means for passing thereto said composite color video signal without said synchronizing pulse, said means for providing said synchronizing pulse having an input coupled in advance of said separating means; and wherein said brightness controlling means includes means for controlling the brightness of the clamped luminance and chrominance components to provide a corrected signal and adder means for combining the corrected signal with the synchronizing pulse to produce said output composite video signal.

19. A color video display apparatus to which is applied a composite color video signal including a chrominance component and a luminance component that fluctuates between a black level and a peak white level about an average brightness level comprising separating means for separating said luminance component and said chrominance component from said composite color video signal; average picture level detecting means having an input coupled to receive the separated luminance component for providing a control signal in response to the detected average brightness level; variable luminance component controlling circuit means having an input to receive the separated luminance component, a signal output from which a corrected luminance component is provided, and a control input to receive said control signal, for controlling the brightness of the separated luminance component so that respective portions of the corrected luminance component corresponding to portions of the separated luminance component at said black and peak white levels are provided substantially at said black and peak white levels, while the average brightness level of said corrected luminance component is provided substantially at a predetermined optimum level; variable chrominance component controlling circuit means having an input to receive the separated chrominance component, a signal output from which a corrected chrominance component is provided, and a control input to receive said control signal, for controlling the strength of the separated chrominance component, and having an input-output characteristic that varies as a function of said control signal; processing circuit means to which said corrected luminance and chrominance components are applied for producing a plurality color signals; and display means for producing a picture in response to said primary color signals.

20. A color video display apparatus according to claim **19**; further comprising minimum value detecting means for detecting the minimum among the levels of said plurality of primary color signals; peak detecting means for detecting the peak value of such detected minimum level and providing a gain control signal in response thereto; luminance gain control means interposed between said separating means and said variable luminance component controlling circuit means for controlling the strength of said separated luminance component in dependence on said gain control signal; and chrominance gain control means interposed between said separating means and said variable chrominance component controlling means for controlling the strength of said separated chrominance component in dependence on said gain control signal.

21. A color video display apparatus according to claim **20**; further comprising an automatic chroma control circuit interposed between said separating means and said chrominance gain control means.

* * * * *

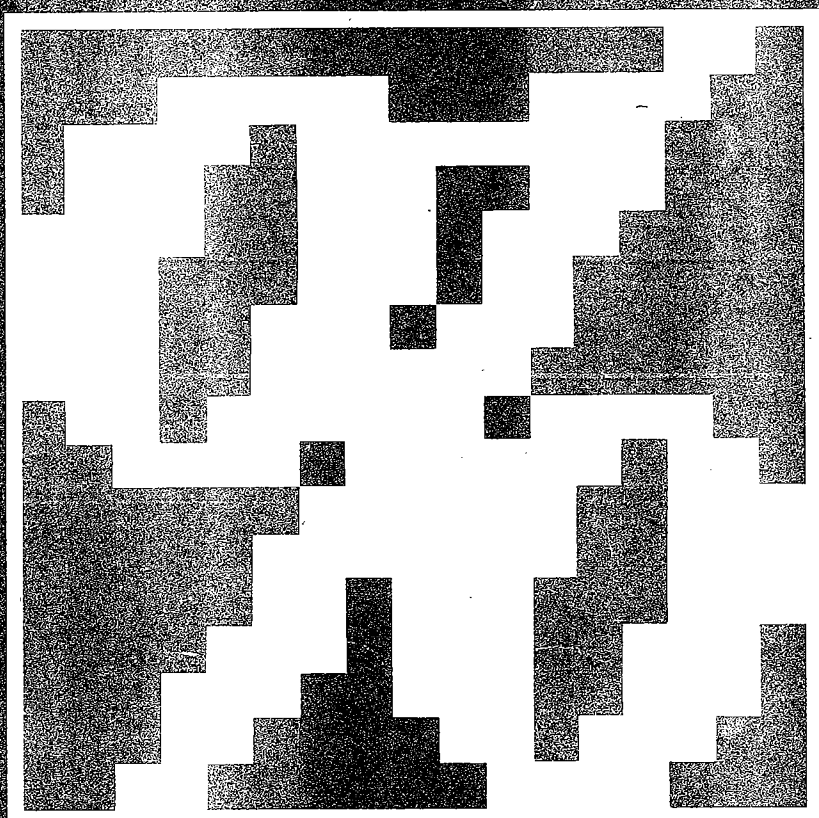
EXHIBIT 4

REDACTED

EXHIBIT 5

MATH IN ACTION

DECIMALS and PERCENTS



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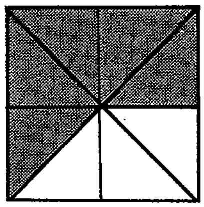
7 8 9 0 1 2 3 4 5 6 D—P 0 9 8 7 6 5 4 3 2 1

Writing Ratios

Look at this shape. It is divided into 8 equal parts. Some of those parts are shaded. How many parts are shaded compared to the total parts?



To show how many shaded parts there are compared to the total parts, we can write a ratio like this:

shaded parts : total parts

5 : 8

When we write a ratio like that, we use a *colon* (:). The colon separates the number of parts from the number of total parts. Which number shows the parts: the number before or after the colon? Which shows the total parts: The number before or after the colon?

To read ratios that compare a part to its whole amount, we say the number of parts is "out of" the total number of parts. For example, read 5 : 8 like this: *five out of eight.*

Exercise

Read these ratios out loud. Which number shows the parts? Which number shows the total parts?

1. 6 : 12
2. 3 : 10
3. 9 : 20
4. 4 : 10
5. 16 : 100
6. 20 : 100

Answers:
1. 6 parts, 12 total parts
2. 3 parts, 10 total parts
3. 9 parts, 20 total parts
4. 4 parts, 10 total parts
5. 16 parts, 100 total parts
6. 20 parts, 100 total parts

Writing Ratios as Fractions

You learned to write ratios with a colon like this:

shaded parts : total parts

5 : 8

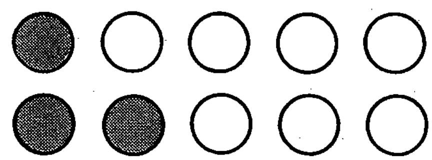
You can also write a ratio so that it looks like this:

$\frac{5}{8}$ **shaded parts / total parts**

Notice that the ratio now looks like a fraction. That's because a ratio *is* a fraction. A fraction shows how many parts there are out of a total of parts.

Which term of the fraction shows the part? Which term shows the total parts? Right. The numerator shows the part. The denominator shows the total parts.

Look at this group of shapes. How many shapes are there in all? How many shapes are shaded?



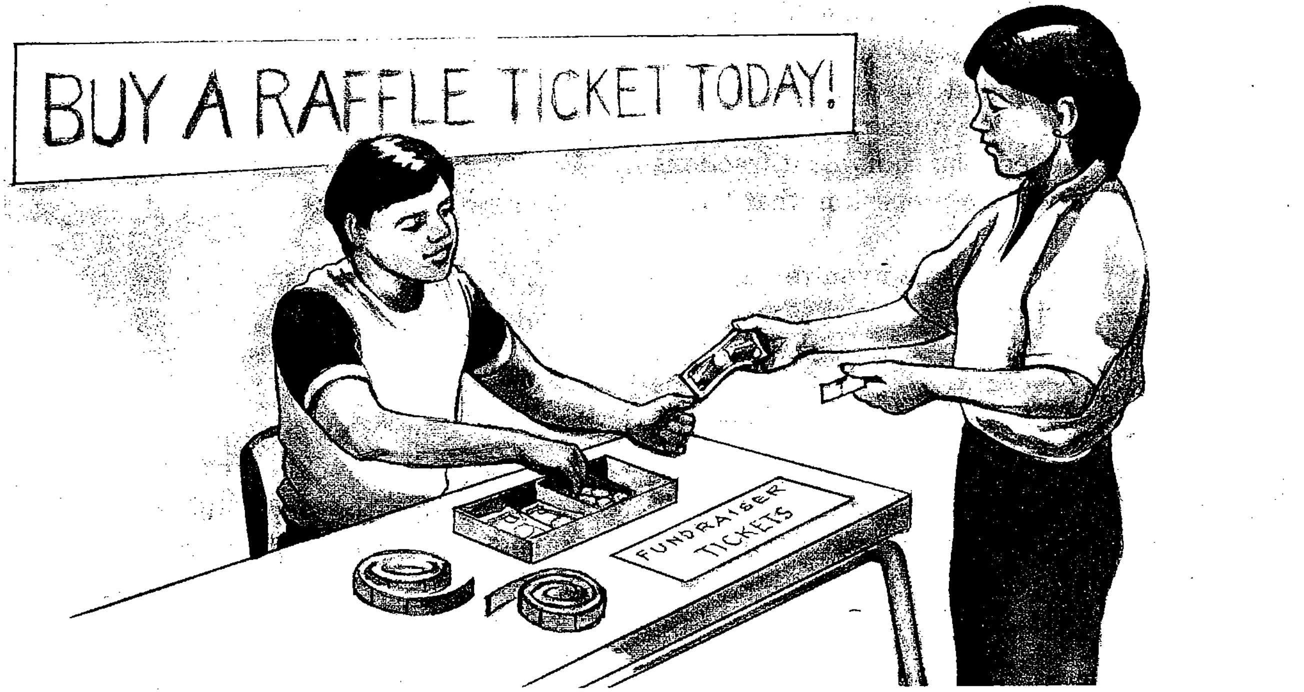
Right. There are ten shapes in all. Three out of the ten shapes are shaded.

a. Write a ratio that compares the shapes that are shaded to the total number of shapes. Write the ratio as a fraction.

b. Write a ratio that compares the shapes that are *not* shaded to the total number of shapes. Write that ratio as a fraction.

Answers: **a.** $\frac{3}{10}$ **shaded shapes / total shapes** **b.** $\frac{7}{10}$ **shapes not shaded / total shapes**

Renaming Decimals and Percents



Imagine this:

Your club is having a fund raiser. You're selling tickets. They cost a *half dollar* (or $\frac{1}{2}$ of a dollar). Someone buys a ticket from you. She gives you a dollar bill. You give her *50 cents* back (or 50% of 100 cents). You must keep a list of all the money you take in. So you write .50 (or *50 hundredths*) on that list.

$\frac{1}{2}$ is a common fraction. 50% is a percent. And .50 is a decimal. They are three different ways to show the same thing. They are three different kinds of fractions.

You can rename each kind of fraction as the other two kinds of fractions. In other words, you can rename fractions as equivalent decimals and percents. You can rename decimals as equivalent fractions and percents. And you can rename percents as equivalent fractions and decimals. You'll learn how to do that in this unit.

Why do you think you'd need to rename decimals, percents, or fractions as equivalents?

One reason is this: Sometimes it's easier to find the answer to a problem if you rename it. For example, look at these two math problems. They are alike. Each asks you to subtract the same amount. Which is easier to subtract?

$\frac{3}{4} - \frac{1}{2}$ or $\begin{array}{r} .75 \\ -\ .50 \\ \hline \end{array}$

Math Word

Look up this word in the glossary. What does it mean?

simplify